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CONTENTS

Page

AUBERTIN, D., M.Sc., F.L.S. Revision of the genus *Lucilia* R.-D. (Diptera, Calliphoridae). (With 30 Text-figures.) 389

BADCOCK, H. D., M.A., F.Z.S. Reports of an Expedition to Paraguay and Brazil in 1926–7, supported by the Trustees of the Percy Sladen Memorial Fund and the Executive Committee of the Carnegie Trust for the Universities of Scotland. Arachnida from the Paraguayan Chaco. (Communicated by Dr. G. S. CARTER.) (With 39 Text-figures.) 1

BEADLE, L. C. Scientific results of the Cambridge Expedition to the East African Lakes, 1930–1.—3. Observations on the bionomics of some East African swamps. (Communicated by Dr. E. B. WORTHINGTON.) (With 6 Text-figures.) 135

—— —— 4. The waters of some East African Lakes in relation to their fauna and flora. (Communicated by Dr. E. B. WORTHINGTON.) (With 7 Text-figures.) 157

—— —— 13. Adaptation to aerial respiration in *Alma emini* Mich., an Oligochaet from East African swamps. (Communicated by Dr. E. B. WORTHINGTON.) (With 2 Text-figures.) 347

BEAUCHAMP, P. DE. Scientific results of the Cambridge Expedition to the East African Lakes, 1930–1.—6. Rotifères et Gastrotriches. (Communicated by Dr. E. B. WORTHINGTON.) (Avec 4 figures dans le texte.) 231

BOSCHMA, Dr. H. The Rhizocephala in the collection of the British Museum. (Communicated by Dr. W. T. CALMAN, F.R.S., F.L.S.) (With 53 Text-figures, including Plate 7.) 473

CALMAN, Dr. W. T. *See* BOSCHMA, Dr. H.

CARTER, G. S., M.A., Ph.D., F.L.S. Reports of the Cambridge Expedition to British Guiana, 1933. Illumination in the rain forest at ground-level. (With 1 Text figure.) 579

—— *See* BADCOCK, H. D.; KREIS, Dr. H. A.

Page

CHAPMAN, F., A.L.S., Hon. F.R.M.S., F.G.S., PARR, W. J., F.R.M.S., and COLLINS, A. C., A.R.V.I.A. Tertiary Foraminifera of Victoria, Australia.—The Balcombian Deposits of Port Phillip. Part III. (Plates **8–11**.) 553

COCKS, F. E. *See* GRIFFITHS, B. MILLARD.

COLLINS, A. C. *See* CHAPMAN, F.

DENNELL, R., B.Sc. The habits and feeding mechanism of the Amphipod *Haustorius arenarius* Slabber. (Communicated by Prof. W. GARSTANG.) (With 13 Text-figures.) 363

FINNEGAN, S., B.Sc., Ph.D., F.L.S. Report on the scorpions collected by Mr. Bertram Thomas in Arabia. (With 8 Text-figures.) 91

GARSTANG, Prof. W. *See* DENNELL, R.

GORDON, I., D.Sc., Ph.D., F.L.S. Scientific results of the Cambridge Expedition to the East African Lakes, 1930–1.—14. Crustacea Macrura (Prawns). (With 7 Text-figures.) 351

GRIFFITHS, B. MILLARD, D.Sc., F.L.S., and COCKS, F. E. Studies in the Phytoplankton of the Lowland Waters of Great Britain.—No. VI. The Rotifer Fauna associated with the Phytoplankton of twenty-eight Lowland Waters 465

HOPWOOD, A. TINDELL, D.Sc., F.L.S. Miocene Primates from Kenya. (Plate **6**.) 437

HORA, Dr. S. L. *See* LELE, S. H.

IMMS, Dr. A. D., F.R.S. Scientific results of the Cambridge Expedition to the East African Lakes, 1930–1.—10. On some Aquatic Coleopterous Larvae. (With 1 Text-figure.) 301

IYENGAR, M. O. P., M.A., F.L.S. Contributions to our knowledge of the Colonial Volvocales of South India. [Title only.] 472

JACZEWSKI, Dr. T. Scientific results of the Cambridge Expedition to the East African Lakes, 1930–1.—12. Aquatic Heteroptera. (Communicated by Dr. E. B. WORTHINGTON.) (With 1 Text-figure.) .. 343

KREIS, Dr. H. A. Reports of an Expedition to Paraguay and Brazil in 1926–7, supported by the Trustees of the Percy Sladen Memorial Fund and the Executive Committee of the Carnegie Trust for the Universities of Scotland. Fresh-water Nematoda from the Paraguayan Chaco. (Communicated by Dr. G. S. CARTER.) (With 11 Text-figures.) 55

Page

LELE, S. H. The circulation of blood in the air-breathing chambers of *Ophiocephalus punctatus* Bloch. (Communicated by Dr. S. L. HORA.) (With 4 text-figures.) 49

LUNDBLAD, Dr. O. Scientific results of the Cambridge Expedition to the East African Lakes, 1930 1.—8. Hydracarina (Communicated by Dr. E. B. WORTHINGTON.) (With 13 Text-figures.) 277

MOORE, J. PERCY. Scientific results of the Cambridge Expedition to the East African Lakes, 1930-1.—9. Leeches. (Communicated by Dr. E. B. WORTHINGTON.) 297

PARKER, H. W., B.A. Scientific results of the Cambridge Expedition to the East African Lakes, 1930–1.—5. Reptiles and Amphibians. (Communicated by Dr. E. B. WORTHINGTON.) (With 10 Text-figures.).. 213

PARR, W. J. *See* CHAPMAN, F.

RICH, F., M.A., F.L.S. Scientific results of the Cambridge Expedition to the East African Lakes, 1930–1.—7. The Algæ. (With 4 Text-figures.) 249

SCOTT, Dr. HUGH. *See* UVAROV, B. P.

TREWAVAS, E., B.Sc. Scientific results of the Cambridge Expedition to the East African Lakes, 1930-1.—11. The Cichlid Fishes. (Communicated by Dr. E. B. WORTHINGTON.) (With 6 Text-figures.) 309

UVAROV, B. P. Entomological Expedition to Abyssinia, 1926–7: Orthoptera of the families Mantidæ, Gryllidae, Tettigoniidae, and Acrididae. (Communicated by Dr. HUGH SCOTT, F.L.S.) (With 10 Text-figures.) 591

WORTHINGTON, E. B., M.A., Ph.D., F.L.S. Scientific results of the Cambridge Expedition to the East African Lakes, 1930–1.—1. General introduction and station list. (Plates 1-5.) 99

—— —— 2. Fishes other than Cichlidae. (With 5 Text-figures.) 121

See BEADLE, L. C.; BEAUCHAMP, P. DE; JACZEWSKI, Dr. T.; LUNDBLAD, Dr. O.; MOORE, J. PERCY; PARKER, H. W.; TREWAVAS, E.

ERRATA

Plate 5, No. 4, *for* Lake Naivasha *read* Lake Baringo.

No. 5, *for* Lake Bunyoni *read* Lake Naivasha.

Page 119, line 3 from bottom, *for* Lake Naivasha *read* Lake Baringo.

last line, *for* Lake Bunyoni *read* Lake Naivasha.

189, Table, line 4, for *Diapanosoma* read *Diaplanosoma*.

195, Table, line 5, for *Monia* read *Moina*

274, line 17, for *Colothrix* read *Calothrix*.

351, line 15, *for* Cardina *read* Caridina.

357, line 10 from bottom, for *E. africana* read *C. africana*.

396, line 21, for *caerulia* read *caerulea*.

405, line 5, for *caerulia* read *caerulea*.

434, line 4 from bottom, *for* caerulia *read* caerulea.

468, line 2, *for* Wiezejski *read* Wierzejski.

EXPLANATION OF THE PLATES

PLATE

1–3. East African Lakes.

4. Maps of East African Lakes.

5. Lake Baringo. Lake Naivasha.

6. *Limnopithecus*, *Xenopithecus*, and *Proconsul*.

7. *Sacculina sinensis* *Ptychascus glaber*.

8–11. Victorian Tertiary Foraminifera.

THE JOURNAL

OF THE

LINNEAN SOCIETY OF LONDON

(ZOOLOGY)

Reports of an Expedition to Paraguay and Brazil in 1926–7, supported by the Trustees of the Percy Sladen Memorial Fund and the Executive Committee of the Carnegie Trust for the Universities of Scotland.

Arachnida from the Paraguayan Chaco.

By H. D. Badcock, M.A. Oxon, F.Z.S. (Communicated by Dr. G. S. Carter, M.A., Ph.D., F.L.S.)

(With 39 Text-figures.)

[Read 12 May 1932.]

The Arachnida listed in this paper were collected by Dr. G. S. Carter and Mr. L. C. Beadle during their stay in South America in 1926–7, an account of which is given in Proc. Roy. Phil. Soc. Glasgow, vol. lvi, p. 82, and in Journ. Linn. Soc. London, vol. xxxvii, p. 205. By far the greater number were taken in the Gran Chaco on the Paraguayan side of the Bolivian border, or from the district bordering on the São Paulo–Matto Grosso Railway in southern Brazil.

The total number of species of spiders is 53, 40 of which I have been unable to refer to any previously described; and of Solifugae 1, also new. The Pedipalpi are not here dealt with. The collection comes nowhere near being a complete representation of the Arachnida of the district. In particular, no example of the Mygalomorpha is present, but the absence of this or other groups must not be taken to indicate that they are not found in the district.

I have to thank Dr. Carter for making the drawings to illustrate the paper, and also for many valuable notes.

In the descriptions I have used Lankester's terms Prosoma and Opisthosoma for the main divisions of the body, retaining Cambridge's Caput and Thorax for the parts of the former.

The following abbreviations have been used :—

pen. ♂	♂ in its penultimate moult.
Ps.	Prosoma.
Os.	Opisthosoma.
I, II, III	For the rows of eyes.
1, 2, 3, 4	For the individual eyes, 1 being central anterior, 2 lateral anterior, 3 central posterior, 4 lateral posterior. The eyes of row II in the Lycosidae and Salticidae are considered as 3. 1 . 2, etc., means the distance between adjacent edges of eyes 1 and 2. The length of I means that between outer edges, e.g. in the Lycosidae $I=2+2.1+1+1.1+1+1.2+2$.
Quad.	Quadrilateral. In the case of eyes, this always means the circumscribing quadrilateral.
$<, =, >$	Have their usual meanings. When two of them occur together, e.g. $\geqq$, it is to be understood that the difference is so slight as to be negligible in some specimens.
U.	Upper row of teeth, i.e. that on the edge of the falx furthest from the maxilla.
L.	Lower row of teeth. The teeth themselves are numbered 1. 2, 3, etc., 1 being nearest to the root of the unguis.
c, tr, f, p, ti, m, ta	Coxa, trochanter, femur, patella, tibia, metatarsus, tarsus.
u, l, f, h	Upper, lower, fore, hind side of legs, the legs being considered as drawn out at right angles to the axis of the body. Thus ti : l. 1 . 2 . 1 means 'On the lower side of the tibia the spines are arranged 1 near the base, followed by a pair abreast towards the centre, followed by 1 near the apex'. Spines on the apex itself are marked 'ap' Subscript letters refer to the legs. Thus c_1 means the coxa of a first leg, $c_{4.4}$ coxae of the fourth pair.
j_1, j_2	Joints of the pedicel.
s_1, s_2, s_3	Spinners, s_1 being the lower, s_2 the median, s_3 the upper.
Rect.	Rectangular.
Proc.	Procurved, i.e. concave forward.
Rec.	Recurved, i.e. concave backward.

All measurements are in millimetres.

List of species.

Family ZODARIIDAE.

Subfamily Zodariinae.

		Locality.	Page
Nanahua, gen. nov.	*N. carteri*, sp. n.	Nanahua	5

Family PHOLCIDAE.

Subfamily Pholcinae.

Physocyclus Sim.	*P. muricola*, sp. n.	Miranda	7
Blechroscelis Sim.	*B. azurea*, sp. n.	Corcavada	8

Family THERIDIIDAE.

Subfamily Argyrodinae.

Rhomphaea L. Koch.	*R. spinosa*, sp. n.	Miranda	8
Argyrodes Sim.	*A. falcatus*, sp. n.	Makthlawaiya	9
Chacoca, gen. nov.	*C. antherata*, sp. n.	Nanahua	10
	C. flavodorsata, sp. n.	Nanahua	11
	C. distincta, sp. n.	Baurú	11
Latrodectus Walck.	*L. carteri*, sp. n.	Nanahua	12
	L. cretaceus, sp. n.	Makthlawaiya	13
	L. curacaviensis (Muller).	Nanahua	13

Family ARGIOPIDAE.

Subfamily Tetragnathinae.

Tetragnatha Latr.	*T. decipiens*, sp. n.	Nanahua	13
	T. antillana Sim.	Campo Grande	14
	T. parva, sp. n.	Campo Grande	14
Leucauge White.	*L. atrostricta*, sp. n,	Itapura	14

Subfamily Nephilinae.

Nephila Leach.	*N. chacoensis*, sp. n.	Makthlawaiya	16
	N. dubia, sp. n.	Nanahua	17

Subfamily Argiopinae.

Argiope Aud.	*A. simplex*, sp. n.	Makthlawaiya	17
	A. argyrea, sp. n.	Nanahua	19
Acacesia Sim.	*A. lanceolata*, sp. n.	Nanahua	20
Eustala Sim.	*E. tribrachiata*, sp. n.	Nanahua	20
Araneus Clerck. (Series A.—Without tuberculations.)	*A. nordenskioldi* Tullgr.	Makthlawaiya and Nanahua	22
	A. gregalis (Cambr.).	Campo Grande	23
	A. deliciosus (Keys.).	Miranda	23
	A. versicolor (Keys.).	Nanahua	23
	A. inexplicabilis, sp. n.	Nanahua	23
(Series B.—Tuberculated.)	*A. rugosus*, sp. n.	Corcavada	24
	A. carteri, sp. n.	Corcavada	25
	A. cylicophorus, sp. n.	Miranda	26
	A. pentacanthus (Walck.).	Makthlawaiya	27
Gasteracantha Sund.	*G. cancriformis* (L.).	Itapura	27
Micrathena Sund.	*M. silvicola*, sp. n.	Makthlawaiya	27

Family THOMISIDAE.

Subfamily MISUMENINAE.

		Locality.	Page
Misumena Latr.	*M. viridis*, sp. n.	Nanahua	29
	M. ignobilis, sp. n.	Nanahua	29
	M. pulchra, sp. n.	Nanahua	30

Family PLATORIDAE.

Vectius Sim.	*V. niger* (Sim.).	Miranda, Nanahua, Rio Verde, Makthlawaiya	30

Family CTENIDAE.

Subfamily ACANTHEINAE.

Nothroctenus, gen. nov.	*N. stupidus*, sp. n.	Nanahua	31

Family CLUBIONIDAE.

Subfamily LIOCRANINAE.

Syrisca Sim.	*S. agalenoides*, sp. n.	Nanahua	32

Family PISAURIDAE.

Dyrinoides, gen. nov.	*D. onychiatus*, sp. n.	Miranda	33
	D. minutus, sp. n.	Campo Grande.....	34
Dossenus Sim.	*D. marginellus*, sp. n.	Itapura	35

Family LYCOSIDAE.

Lycosa Latr.	*L. nanahuensis*, sp. n.	Nanahua	36
	L. albimarginata, sp. n.	Makthlawaiya	37

Family SALTICIDAE.

Division *PLURIDENTATI*.

Psecas C. Koch.	*P. splendida*, sp. n.	Makthlawaiya	38
	P. pulchra, sp. n.	Makthlawaiya	39
Sitticus Sim.	*S. brutus*, sp. n.	Nanahua	40
Camponia, gen. nov.	*C. [illegible]ata.*	Campo Grande	40
Breda Peck.	*B. quinquedentata*, sp. n.	Makthlawaiya	42

Division *UNIDENTATI*.

Plexippus C. Koch.	*P. paykulli* (Aud.).	Campo Grande	42
	P. albicrinitus, sp. n.	Nanahua	43
	P. luteus, sp. n.	Nanahua	44
Makthalia, gen. nov.	*M. cincta.*	Makthlawaiya	45

Division *FISSIDENTATI*.

Rudra Peck.	*R. baurensis*, sp. n.	Baurú	46
Mirandia, gen. nov.	*M. australis.*	Miranda	47

SOLIFUGÆ.

Family SOLPUGIDAE.

Subfamily DAESIINAE.

Mummucia Sim.	*M. dubia*, sp. n.	Nanahua	48

Family ZODARIIDAE.

Subfamily ZODARIINAE.

Genus NANAHUA, gen. nov.

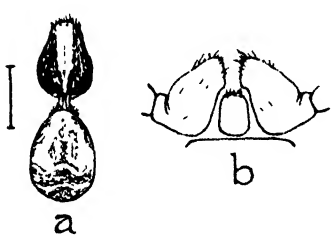
NANAHUA CARTERI, sp. n. (Text-fig. 1.)

This species is undoubtedly allied to *Storena*, but the eye-arrangement seems to demand a separate genus. From no point of view can row II be called 'validissime procurvum' (*Storena*, Simon (I), p. 429), nor can the eyes 4 . 1 . 1 . 4 possibly be considered as one row. The clypeus also is not vertical, but incurved.

Imm. ♀, 8·0.

General description.—Lycosid-like. *Ps*. with broad chocolate sides separated by a broad light central marking whose sides are parallel on the caput, slightly narrowing with wavy edges to behind the fovea, and then constricted, reaching the base as a narrow strip. Sternum and legs much the same colour as the central band, but the legs rather clouded on femora.

TEXT-FIG. 1.



TEXT-FIG. 2.

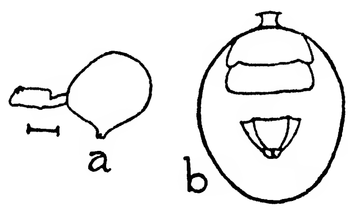


Fig. 1.—*Nanahua carteri*, ♀. *a*, from above; *b*, maxillae and labium.
Fig. 2.—*Physocyclus muricola*, ♀. *a*, profile; *b*, from below.

Os. Dark brown, with lighter brown chevrons, streaks, and spots.

Ps. Front slightly rounded, with very coarse black hairs projecting forward. About one-third width of thorax. A thin red streak down centre of central band on caput. Fovea red, deep, short, longitudinal. Striae distinctly present, but chiefly defined by light ridges between them. Base cut off nearly square, rather wider than front.

Sternum. Shield-shaped, slightly longer than broad, straight in front, point behind just level with front of $c_{4.4}$, which are subadjacent. A few coarse black hairs, especially near hinder margins.

Eyes. Clypeus re-entrant, about = quad., with very coarse black hairs. Quad. longer than broad, very slightly broader in front. Order, perhaps, 2=4 . 1=3, but very nearly equal. The eyes are so situated that it is difficult to get a true idea by looking at them either from directly before or above.

For estimating curve the spider must be held so that the quad. is horizontal. We then get :—

I. Slightly proc., subadjacent. $1\leqq 2$.

II. About equally proc. $3.3=\frac{1}{2}\times 3$. $3.4>2\times 3$. $3<4$.

Falces. Some black hairs in front. On front view, slightly narrower at unguis ; from side, triangular, very stout at base. No furrow, but teeth U 2, of which the second is very small and slightly beyond angle and tip of unguis.

Rostrum. Rather thick, lance-shaped, hairs at tip, extending well beyond labium.

Maxilla. Stout scapula at outer front edge. No serrula. (See text-fig. 1 *b*.)

Labium. Longer than broad, slightly tapering. (See text-fig. 1 *b*.)

Palpi. Stout, with claw of about six pectinations.

Spines stout and thick on f, p, ti, and most on ta. ta>ti>p.

Legs. No scopula or onychium. Paired claws strong, with about ten pectinations, subequal, and reaching well beyond bend. Single claw short, but rather stout, rather bent than elbowed. I think without pectinations.

1, 6·7 ; 2, 6·0 ; 3, 6·0 ; 4, 8·4. 4 . 1 . 2=3.

Spines : $f_{1.2}$ u. 1 . 1, $f_{3.4}$ 1 . 1+at least 2 apical.

$p_{1.2}$ none, $p_{3.4}$ 1 at each side+1 u apical.

ti_1 l. 1 . 1+a long fine erect bristle under base.

ti_2 as ti_1, but without bristle.

$ti_{3.4}$ several all round, rather more numerous on 4.

$m_{1.2}$ l. 2 . 2 . 2.

$m_{3.4}$ numerous all round, especially strong at apex u.

ta_1 l. 1 . 2, ta_2 l. 2 . 2, $ta_{3.4}$ about l. 5 rather irregular.

The spines are short but stout.

Pedicel. Upper plates 2 about equal in length, but the front one slightly broader, with convex end to meet a concavity of j 2. There seem to be a pair of short lateral plates projecting on either side from the ps.

Os. Epigaster. Dark in centre, with large light spiracular plates and a pair of small light round spots in front of rima.

Epigyne. Undeveloped.

Spinners. s_1 adjacent long and stout with common membranous base, with (if any) a very short terminal joint. Large spigots on front inner edge and several spools.

s_3 much smaller and wider apart, so that their inner edge is about level with outer edge of s_1. Second joint is much longer in proportion, several spools at top.

s_2 very much smaller and in straight line with s_3.

Simon's figs. 400 and 401 for *Storena* (i, p. 427) apply to these spinners, except that in the present species s_1 has a longer membranous base and s_2 is not quite so short in proportion.

Colulus. None.

Nanahua, March 1927.

Family PHOLCIDAE.

Subfamily PHOLCINAE.

Genus PHYSOCYCLUS Simon (I, vol. i, p. 420).

PHYSOCYCLUS MURICOLA, sp. n. (Text-fig. 2.)

Simon's genus *Physocyclus* (i, p. 470) is described as having the posterior legs much longer than the anterior, whereas in all the specimens I have examined in the British Museum the contrary is the case. The statement is therefore probably a misprint, and I include this species in *Physocyclus*, of which it has all the characteristics.

♀, 4·0 ; pen. ♂, 3·6.

General description.—Ps. Light yellow with deep fovea, a central broad darker marking behind which is produced in front of fovea by a central (in ♂ only) and a pair of thin lateral lines to the eyes ; outer ends of striae and front of falces marked by dark patches. Sternum light in centre with dark shading towards edge. Legs light yellow with narrow annulations near ends of joints.

Os. Grey with obscure markings, leaving a central light band. In ♀ the dark predominates, in ♂ the light. Height much greater than length from spinners forward.

Eyes. Clypeus=nearly 3×quad. Quad. slightly broader than long, much broader behind. Lateral triangles adjacent, but 2 . 3>2 . 4. Order 2 . 4 . 3 . 1.

I. Straight from in front. Adjacent. $1=\frac{2}{3}\times 2$.

II. Slightly rec. from above. 3 very slightly <4. $3 . 3>1\frac{1}{2}\times 3$.

Falces. Flat in front, with a long curved pointed tooth on inner edge just above unguis, which it approximately equals in length in both sexes. With unguis closed this tooth crosses it below and at right angles.

Maxillae. Narrow, parallel-sided, and strongly inclined over labium, with serrula on outer edge near tip.

Labium. United with sternum. Slightly broader than long.

Sternum. Nearly semicircular, straight in front, centre of semicircle cut off straight behind at front of $C_{4.4}$, which are wide apart.

Palpi. f in ♂ and in ♀ quite as long as all subsequent joints combined, slightly clubbed ; p and ti both very small, ti>p ; ta considerably>p+ti.

Legs. ♂, 1, 24·5 ; ♀, 15·1.
2, 17·6 ; 10·4. No spines.
3, 14·8 ; 9·0.
4, 18·7 ; 11·8.

In both sexes 4 is thus only slightly >2 and much <1, whereas Simon's diagnosis of the genus (i, p. 470) gives 'pedes postici anticis multo longiores'.

Genital plate. Very large and broad and subrectangular, with its distal end at least twice as far from pedicel as from spinners. (See text-fig. 2 *b*.)

Miranda, 5 Sept. 1926. Numerous on walls of hotel.

Genus BLECHROSCELIS Simon (I, vol. i, p. 483).

BLECHROSCELIS AZUREA, sp. n. (Text-fig. 3.)

♂, 3·0 ; ♀, 4·9.

This species is only distinguished from *B. cyaneotaeniata* Keys. (Keyserling, 6, p. 176, pl. vi, fig. 121), which has been recorded from Brazil, by the male palpus, which has on the tarsus three very distinct processes pointing forward, of which the centre one is the strongest (see text-fig. 3 and Keyserling's fig.). The markings and the ♀ epigyne are essentially the same. Comparison of a specimen of *B. cyaneotaeniata* in British Museum confirms Keyserling's figure.

Corcavada, Rio de Janeiro, 3 Aug. 1926.

TEXT-FIG. 3.

TEXT-FIG. 4.

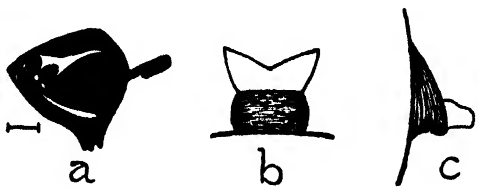


Fig. 3.—*Blechroscelis azurea*, ♂. Palpus.
Fig. 4.—*Argyrodes falcatus*, ♀. *a*, profile ; *b*, epigyne from behind ; *c*, epigyne from side.

Family THERIDIIDAE.

Genus RHOMPHAEA L. Koch (Simon, I, vol. i, p. 502).

RHOMPHAEA SPINOSA, sp. n.

This species is very closely allied to *R. paradoxa* Tacz. (Taczanowski, 12, p. 58, pl. v, fig. 13, and Keyserling, 6, p. 168, pl. viii, fig. 103, sub *Ariamnes*), from which it can only be distinguished by (1) eyes 3 . 3 are *at least* two diameters apart and not ' nearly one ', (2) small round brown line is on epigaster and only just touches the front of venter.

In view of the fact that the ' thorn ' at the vertex of *R. paradoxa* is a marked feature of this specimen, I feel much tempted to identify them, but the first of the above differences (unless Keyserling is mistaken) seems to make it necessary to create a new species. *R. paradoxa* has been recorded from Guiana.

Simon's figure (I, vol. i, p. 500, fig. 507) of an undescribed species from Venezuela (called *R. simoni* by Petrunkevitch) might well refer to this species, except for the absence of the ' thorn '.

No other species have been recorded from S. America.

Miranda, 6 Sept. 1926.

Genus ARGYRODES Simon (I, vol. i, p. 503).

ARGYRODES FALCATUS, sp. n.* (Text-fig. 4.)

Found on the web of *Nephila chacoensis.*

♀, 3·9.

General description.—Ps. Dorsum and sternum very dark brown or black. Legs light yellow, annulated dark brown at ends of joints, except 1, which has f, t, ti black throughout.

Os. Black, with a pair of axe-shaped cretaceous silver markings on dorsum, the axes being back to back and the blades (which are at the hinder end) cleft. Behind these a pair of silver blotches. On each side a narrow silver line in front and a blotch behind. Below, a pair of silver blotches behind spinners, 3 spots in front of spinners, and a transverse line behind rima (text-fig. 4 *a*).

Eyes. Clypeus rather projecting but hollowed below. 1 . 1=quad. Quad. very slightly broader than long, slightly broader in front than behind. Laterals adjacent on tubercle.

I. Straight from in front, and very strongly rec. from above. 1 . 1 on forward projection. 1=nearly 2×2. 1 . 1=2×1=1 . 2.

II. Slightly rec. 3 . 3=2×3=3 . 4.

Falces. Long, rather narrow, with very large basal spot. Teeth U 3, 3 much largest, L 1 level with U 3.

Maxillae. Very slightly inclined and very slightly marginated on outer edge.

Labium. Rounded, united with sternum, about $\frac{1}{2}$×max., as broad or slightly broader than long.

Sternum. Triangular, much longer than broad, and produced between $c_{4.4}$, which are about their width apart, convex, smooth.

Palpi. Dark brown. Ti considerably <ta ; p very small. Claw does not appear to be pectinated.

Legs. Damaged, but 1 certainly very much the longest, and ti much >m. 3 shortest. Claw 3 at least as large as paired claws, which are of unequal size.

Epigyne. See text-fig. 4 *b*, *c*.

Makthlawaiya, 14 April 1927.

Genus CHACOCA, gen. nov.

The species I have placed under this genus seem to be transitional forms between *Theridion* and *Latrodectus.* They are separated from the former by the absence of a tooth on the upper margin of the falces and by the distinct separation of the lateral eyes. These in *C. antherata* are very close, and in the others more than half a diameter apart. They are, however, in all cases much nearer than in *Latrodectus.*

* This specimen has unfortunately been lost since the description and drawings were made.

Chacooca antherata, sp. n. (Text-fig. 5.)

♂, 2·9. Ps. 1·2×1·0. Os. 2·0×1·7.

General description.—A very distinctly marked spider. *Ps.* Dorsum, sternum, and legs mahogany, the first with dark marginal markings nearly as broad as central band, the last with almost black femora.

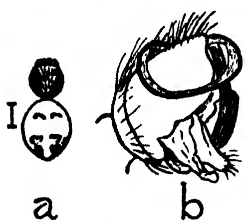
Os. Yellowish. A pair of irregular brown spots, followed by another pair confluent with longitudinal bands to spinners, the general appearance being that of stamens of a flower with their anthers. Lower sides, epigaster, and venter black, except for a pair of light markings below rima, and a larger one in front of spinners.

Eyes. Clypeus $=$ quad., $<$ falces, hollowed below eyes. Quad. square. Laterals adjacent. Order 1 . 2 $=$ 3 . 4.

I. Straight or very slightly proc. from before. 1 . 1 (on prominence) $=$ 1 much $>$ 1 . 2.

II. Slightly rec. 3 . 3 $=$ 3 $>$ 3 . 4.

Text-fig. 5.



Text-fig. 6.

Text-fig. 7.

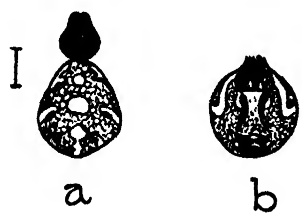


Fig. 5.—*Chacoca antherata*, ♂. *a*, from above; *b*, palpus.
Fig. 6.—*Chacoca flavidorsata*, ♀.
Fig. 7.—*Chacoca distincta*, ♀. *a*, from above; *b*, os from below.

Falces. Teeth none.

Maxillae. Inclined.

Labium. Broader than long, rounded apex.

Sternum. Very slightly longer than broad, straight in front, produced between $c_{4.4}$, which are nearly their width apart. Convex, smooth.

Palpi. Light yellow. p small, almost cubical; ti very short, broad, and with a long flattened apophysis on outer side, the whole looking like the calyx of a flower under its corolla (the ta); ta large, cup-like, with long apophysis on lower edge projecting beyond the flat top. The organs lie completely in the cup, but the large style issues from centre, completely circles the edge of the cup twice, then turns backwards still curling outside ta to reach base of p in one palp, and in the other makes another circle and returns outside bulb to rim. Ta is only hemispherical as seen from the end, the rim being formed by the style, below which it is open nearly to base of ta. Simon's fig. 576 (I, vol. i, p. 562) of the palp of *Latrodectus* 13-*guttatus* bears a very strong resemblance.

Legs. 1, 7·5 ; 2, 5·1 ; 3, 3·0 ; 4 damaged, but order certainly 1 . 4 . 2 . 3.

The claws are difficult, but there is undoubtedly a large curved pectination near the end, preceded by some small ones, the type being rather theridiid than latrodectine.

A ♀ taken from the same place a month earlier seems to be the same species, but it is so damaged as to be useless.

Nanahua, March 1927.

CHACOCA FLAVODORSATA, sp. n. (Text-fig. 6.)

♀, 4·7. Ps. 1·8×1·5. Os. 2·9×2·5.

General description.—*Ps.* Caput, central line, thorax behind fovea, and very broad margins dark brown, leaving only a pair of light markings convex towards centre on either side of central line. Sternum dark brown, with central longitudinal marking from apex not quite reaching labium. Legs light yellow, strongly annulated black at ends of joints.

Os. Light cretaceous-yellow. A dark irregular marking concave backwards and connected forward by a very thin central longitudinal line. A similar but narrower band follows, carried right down to meet venter. A pair of irregular spots confluent with irregular bands to spinners, the general appearance that of the anthers of a flower with stamens. Sides crossed by second band, which has a branch upwards near ventral end and another marking behind upwards, level with, but not reaching the anthers. All the above markings are strongly outlined black. Epigaster and boundary of venter black, the whole centre a cretaceous-yellow square.

Eyes. Clypeus slightly>quad., much<falces. Quad. very slightly longer than broad, rect. Laterals 2 . 4=½×2. Order, subequal.

I. Straight from before. 1 . 1>1. 1 . 2=½×1.

II. Slightly rec. 3 . 3=3, very slightly>3 . 4.

Falces. Teeth none.

Maxillae. Inclined.

Labium. Broader than long, rounded apex.

Sternum. As broad as long, straight in front, pointed behind in front of $c_{4.4}$, which are at least their width apart.

Palpi. Light yellow, slightly clouded on p, end of ti and ta.

Legs. Damaged, but probably 1 . 4 . 2 . 3.

Nanahua, March 1927.

CHACOCA DISTINCTA, sp. n. (Text-fig. 7.)

♀, 4·7. Ps. 1·9×1·5. Os. 3·2×2·9.

General description.—*Ps.* Dorsum deep brown with broad but obscure central and marginal bands darker. Sternum the same, but with narrow light yellow central line. Legs light, narrowly banded dark brown at ends of joints.

Os. Greenish cretaceous with three large white spots followed by a white dagger to spinners. Sides cut into by large white markings, all the boundary

between white and green being lined in red. Below, a white marking with concave sides, a pair of white spots outside this in front and another behind, and a single spot in centre. A very distinctly marked spider. (See text-fig. 7.)

Eyes. Clypeus>quad., hollowed below 1 . 1. Quad. square. Laterals 2 . 4>½×2. Order 1=3 . 2=4, subequal.

I. Slightly proc. before, 1 . 1=1>1 . 2, which=½×1.

II. Slightly rec. 3 . 3>3. 3 . 4<3.

Falces. No teeth.

Maxillae. Strongly inclined.

Labium. Broader than long, obtuse.

Sternum. Distinctly longer than broad, bluntly pointed behind in front of $c_{4.4}$, which are nearly their width apart.

Palpi. Light.

Legs. 1, 11·3 ; 2, 7·1 ; 3, 5·2 ; 4, 9·4. 1 . 4 . 2 . 3.

Baurú, 12 Aug. 1926.

Genus Latrodectus Muller.

Latrodectus carteri, sp. n. (Text-fig. 8.)

♀: 8·4, 7·2, 7·0, 6·8, 6·1, 6·0, 5·7.

General description.—Ps. Dorsum chestnut, obscurely shaded towards margin, and with striae reddish. Sternum same. Legs brown with obscure darker shading on f and at end of other joints.

Os. Brownish, a pair of brown cup-shaped markings in front standing by narrow stems on a transverse band, and continued by a pair of irregular longitudinal bands to either side of spinners (see text-fig. 8 *a*), these being connected again about halfway back by a second transverse band broken at the centre. Lower sides dark brown, the main transverse and the hinder longitudinal band joining them. Venter lighter, with a very obscure, slightly darker central band.

Eyes. Clypeus=quad., hollowed below 1 . 1. Quad. very slightly longer than broad. Laterals separated, but 2 . 4<2 and <1 . 3. Order 1 . 2=4 . 3.

I. Proc. from before. 1 . 1$\overline{\overline{<}}$1$\overline{\overline{<}}$1 . 2.

II. Slightly rec. 3 . 3=3 . 4.

Falces. Teeth none.

Maxillae. Inclined.

Labium. Broader than long, rounded.

Palpi. Light brown with ta bristly and slightly darker. ti<ta, much >p. Claw rather large, and with strong pectinations.

Legs (of largest specimen). 1, 16 ; 2, 9 ; 3, 7 ; 4, 13 (approx.). 1 . 4 . 2 . 3.

There is considerable variation in the markings of this spider, chiefly due to the confluence of abdominal markings, but the identity of the epigyne in all is complete (text-fig. 8 *b*).

Nanahua, March 1927.

Latrodectus cretaceus, sp. n.

♀, 8·0.

This is distinguished from *L. carteri* only by the fact that the light ground of the abdomen is cretaceous, and that it has six light spots round the spinners ; in all essential respects including the epigyne, which is not a very distinctive one however, they are alike. The difference between a plain and a cretaceous coloration in specimens of the same species is one that I have never come across, and, provisionally at any rate, I must count it of specific value.

Makthlawaiya, 8 April 1927.

Latrodectus curacaviensis (Muller).

3 ♀: 11·1, 8·0, 7·2.

Carter reports as poisonous.

Nanahua, March 1927.

Text-fig. 8.

Text-fig. 9.

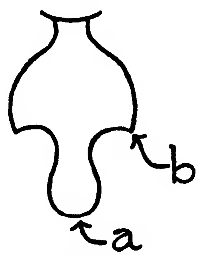


Fig. 8.—*Latrodectus carteri*, ♀. *a*, from above ; *b*, epigyne.
Fig. 9.—*Tetragnatha decipiens*, ♀. *a*, epigyne ; *b*, edge of spiracle.

Family ARGIOPIDAE.

Subfamily Tetragnathinae.

Genus Tetragnatha Latr. (Simon (i), vol. i, p. 723).

Tetragnatha decipiens, sp. n. (Text-fig. 9.)

♀, 8·3.

I can find no essential difference between this and *T. extensa* L., except the position of the epigyne, which in this species (see text-fig. 9 *a*) is behind the line joining the spiracles (text-fig. 9 *b*) by a distance nearly, if not quite, as great as that from the outer edge of a spiracle to the centre, whereas in all the specimens of *T. extensa* I have seen this distance is not much more than a quarter of the same.

In addition there is a large space between teeth L 1 . 2 in *T. extensa*, and the others follow regularly, whereas in this specimen there are moderate and equal spaces L 1 . 2 and L 2 . 3, the regular series beginning at L 3, and the teeth are more numerous.

♀, 8·5. Ps. 3·0 (excluding falces). Os. 6·0. Falces 2 . 2.
Teeth. U 8, L 9 (*T. extensa* about 7, 7 or 7, 6).
Legs. 23·0, 15·8, 7·3, 13·5. 1 . 2 . 4 . 3.
Nanahua, 5 Feb. 1927.

TETRAGNATHA ANTILLANA Simon (5), Cambridge (10, vol. ii, p. 433, pl. xli, figs. 5, 6).

This spider has previously been recorded only from C. America and the West Indies; the dark colouring and especially the large apical tooth parallel to the joint and pointing directly forward, which is said by Cambridge to be found in no other species, seem to prove identity.

♀, 11·0. Ps. 3·6. Os. 8·0. Falces 3·1.

Teeth. U 12. 1 and 2 are outside the row 3–12 and are widely spaced. 1 is strong and at right angles to falx. 1 . 2>2 . 3; 2<3; 3–10 close and decreasing.

L 11–14. 1 outside margin, very large and pointing directly forward; 2 corresponds to U 1. 2 . 3=3 . 4>4 . 5. 5 . 6<4 . 5, but distinctly larger than the remaining spaces beginning at 6. 3 smaller than 2 and 4. Teeth decrease from 4 downwards, but are less than the corresponding U series.

Unguis. Sinuous, with a distinct prominence on the under edge at change of curve.

General appearance.—Very dark, legs with black at extremities of joints.

Campo Grande, stream south of town, 31 Aug. 1926.

TETRAGNATHA PARVA, sp. n.

This is quite possibly a young specimen of a known species with falces undeveloped.

♀, 5·2.

General description.—*Ps.* Yellow, with a broad brown central stripe, bifurcated on the caput, and a moderate brown margin. Sternum brown, with darker margin. Legs light, with narrow black bands at ends of joints.

Os. Rather dark with the normal markings of the genus, the light marginal bands on the belly, with the two following light spots, very distinct.

Falces. Short for the genus and rather stout. Unguis short and evenly curved.

Teeth. U 6, fairly regular with 1 . 2 and 2 . 3 not much larger than the other spaces.

L 7, decreasing from 1 to 7, <teeth U, and spacing even more regular.

Campo Grande, 2 Sept. 1926. Stream east of town.

Genus LEUCAUGE White (Simon (1), vol. i, p. 736, and ii, p. 999).

LEUCAUGE ATROSTRICTA, sp. n. (Text-fig. 10.)

The epigyne of this specimen strongly resembles that of *L. volupis*, Keyserling (8, pl. xviii, fig. 264), which has been recorded from Paraguay, but I cannot reconcile the general description.

1 ♀, 7·2.

General description.—*Ps.* Light yellow; sternum the same with broad black longitudinal marking; legs the same, narrowly banded black at ends of joints.

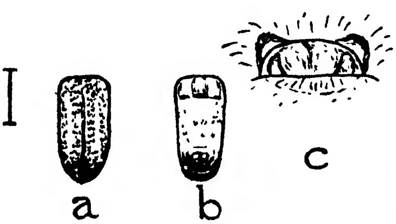
Os. Greenish yellow, with three pairs of longitudinal bands of silver blotches, the central broadest and bent outwards at ends, the third (on sides) very narrow and shorter than the others. Between the central pair a thin darker line expanding over apex to a fusiform black marking, which is horned beyond the apex, a black blotch at the end of the second silver line, and two transverse black lines between apex and spinners.

Epigaster light with reddish band down centre and large dark epigyne. Belly light, with a dark marking projecting forward from spinners, bordered with silver dots. Slight silver marbling at sides in front.

Ps. Cephalic striae very deep, other well marked. Fovea deep and triangular.

Eyes. Clypeus <1. Quad. parallel, very slightly longer than broad. Laterals adjacent on common tubercle.

TEXT-FIG. 10.



TEXT-FIG. 11.

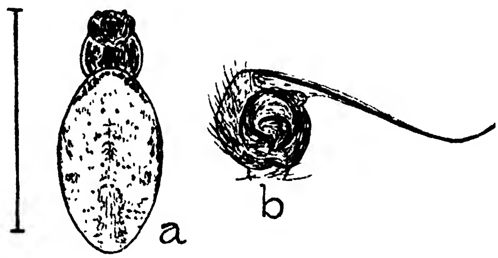


Fig. 10.—*Leucauge atrostricta*, ♀. *a*, os from above; *b*, os from below; *c*, epigyne.
Fig. 11.—*Nephila chacoensis*. *a*, ♀, from above; *b*, palpus.

I. Rec. from before. $1=4>3>4$. $1 . 1<1$. $1 . 3=$abt. 3×1.

II. Slightly rec. from above. $3 . 3=3$. $3 . 4=$nearly 3×3.

Falces. Stoutish and slightly geniculated. A single row of black hairs on U margin.

Teeth. U, 3. 1 . 2 adjacent, 2 largest.
L, 4.

Maxillae. Longer than broad, much broadest in front, with sharp angle at corner and outer edge slightly concave. Dark.

Labium. Broader than long. Dark.

Sternum. Triangular, as broad as long excluding point, which is continued to back of $c_{4.4}$, which are about half their width apart.

Palpi. Light. Tr nearly as long as c_1; ti>2 p; ta$=$nearly 2 ti., with black bristles; claw long and nearly straight with about eight fine pectinations.

Legs. 1, 15·8; 2, 11·7; 3, 6·9. Judging from remaining f_4, order is 1 . 2 . 4 . 3. The legs are much damaged, but there appears to have been a double row of trichobothria on f_4 and a few spines on some m.

Os. Cylindrical, with front rounded and projecting over the Ps.

Itapura, woods, 19 Aug. 1926.

Subfamily Nephilinae.

Genus Nephila Leach (Simon (i), vol. i, p. 755).

Nephila chacoensis, sp. n. (Text-fig. 11.)

Though near to *N. clavipes* L., which is said to be very variable in character, I think it best to describe this as a new species.

♀, 29·2. Ps. 12·0×7·8. Os. 22×7·8.

General description.—Ps. Black with thick grey hairs, with narrow light brown margin. No tubercles. Sternum light brown, with dark transverse bar level with legs 2 and another, recurved, touching the first at centre and terminating level with legs 3; a pair of central short longitudinal markings in front of legs 4. Legs light brown with black terminations, as described later.

Os. Light brown with dark brown streaks and patches strongest on sides and below, quite indescribable. Above, two pairs of red impressions with a third indefinite pair behind and some other small ones irregularly disposed. Below, the stigmatic plates are large, red, and deeply striated, and the belly is outlined by red dashes arranged in beaker shape, and in hinder half of centre are three transverse impressions in longitudinal series.

Eyes. Relative size 1 . 2=4 . 3. 1 distinctly the largest. Laterals on high common tubercle and 2 . 4=3×4.

Falces. Black. Teeth U 3, L 4.

Palpi. Deep red f, merging into black on p, ta.

Legs. 1, 57; 2, 49; 3, 30; 4, 43. 1 . 2 . 4 . 3. All have very short prone spines between f and ti, but there are very few on 4. Tibial brush strongest on 4, absent on 3, covering at least the distal four-fifths of joint on 1, 2, 4. 1, 2 have ta black and end of f clouded. 3, 4 have ta, most of ti, p, and end of f black.

5 ♂: 5·9, 5·4, 4·9, 4·2, 3·8.

In addition to the usual sexual difference in size, the markings are strikingly different to those of the ♀. They were all, however, found on her web, and there can therefore be no doubt of their belonging to the same species.

Differences. Ps is marked by a large light V, including the whole caput, with point at fovea and in some specimens carried on to the base. Sternum is dark with a long central light line from tip of labium to base, which in some specimens is absolutely white in labium, in front of sternum and at base; line is broad in front and narrow behind. The only sign of the dark cross-bars of ♀ is an occasional break across the white centre line in some specimens. Legs are much lighter than in ♀, the only dark markings being a broad ring at end of $ti_{1.2}$ and clouding at end of $f_{1.2}$.

Os has a brownish-yellow ground, with a marking in centre not unlike an egg in its cup, followed by a pair of transverse, and then a pair of short longitudinal markings to spinners, but in most specimens all behind the egg-cup is obscure. Ground-colour in some specimens almost cretaceous. Sides lighter with obscure dark oblique markings. Epigaster dark, with a pair of short longitudinal markings rather wide apart. Belly dark, with a marked white boundary

which is pinched in and sometimes carried across the black, either near centre or close in front of spinners.

Palpus (v. text-fig. 11 *b*).

Legs (of largest specimen). 14·5, 10·7, circ. 5·7, 9·4. 1 . 2 . 4 . 3. Spines less numerous, but much larger than ♀.

Makthlawaiya, 14 April 1927.

NEPHILA DUBIA, sp. n.

3 ♀: 17·9, 12·9, 12·2.

It is possible that these are younger examples of *N. chacoensis*, but they seem mature. The chief differences which induce me to describe this provisionally as a different species are :—

(1) Size.

(2) Os is more cylindrical in shape, and the hinder projection more prominent.

(3) The cross-bars on the sternum are broken by a broad light line down the centre (but cf. ♂ of *N. chacoensis*).

(4) The brown margin to ps is lighter and broader, and there is an obscure light marking from caput to fovea (cf. ♂ of *N. chacoensis*).

(5) The tibial brushes occupy little more than the distal halves of the tibiae, and the legs as a whole are lighter.

(6) The abdominal markings are much more distinct, the dark shadings being almost black.

None of these differences is, however, such as cannot be accounted for by age-development. It is to be noted that *N. chacoensis* was taken a month later.

Nanahua, March (not later than 15th) 1927.

Subfamily ARGIOPINAE.

Genus ARGIOPE Aud. (Simon (I), vol. i, p. 769).

ARGIOPE SIMPLEX, sp. n. (Text-fig. 12.)

This is allied to *A. trifasciata* (Forsk.) (v. *A. fasciata* McCook (14), p. 256), but it is distinguished from it by markings and epigyne.

♀, 17·6. Ps. 6·0×5·6 (½). Os. 13·0×7·0 (½).

General description. *Ps*. Dull yellow with grey hairs. Sternum yellow, with dark border ornamented with yellow spots opposite legs 1–3, the last merging across the border with the yellow of the centre. *Legs* dull yellow, with narrow brown rings, strongest on f.

Os. Fusiform, corrugated. In spirit, dull light yellow, but there are indications of the corrugations having been originally coloured light and dark yellow (perhaps reddish) alternately—at any rate at the hinder end.* Four narrow longitudinal brown lines from just behind centre to spinners. A transverse row of spots in front, and three pairs of spots between these and the com-

* Dr. Carter has a note that the abdomen was silky white in life. It is still covered with fine prone white hairs, which now, however, do not conceal the colour of the epidermis

mencement of the brown lines. Sides and belly dark brown, with a shield-shaped yellow marking on epigaster and yellow bands between belly and sides reaching nearly round spinners and cutting in in front of them. Spinners nearly one-third distance from apex to rima.

Eyes. Clypeus about 2×1. Quad. slightly longer than broad, and narrower in front.

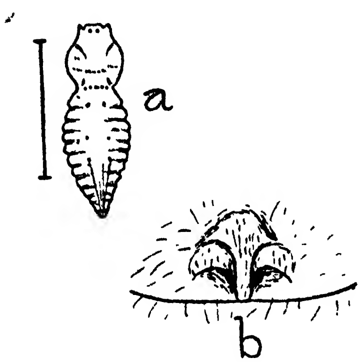
I. Slightly proc. from in front. 2 very small. 1 . 1>1. 1 . 2 about 2×1.

II. Proc. from above. 3>1, 4 about=1, 3 . 3>3, 3 . 4=3×3.

Falces. Light yellow.

Teeth. U 3, 2 greatest; L 3, 3 greatest.

TEXT-FIG. 12.



TEXT-FIGS. 13 & 14.

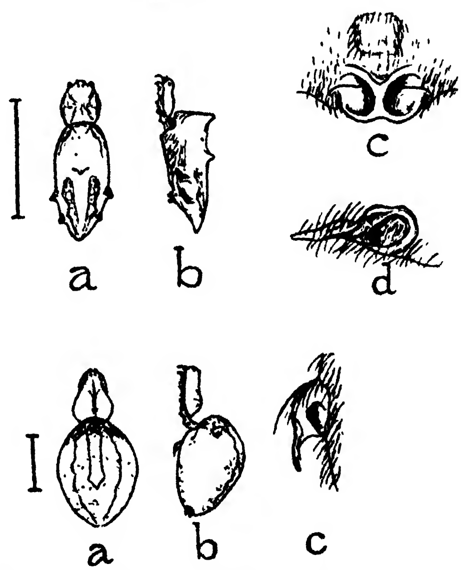


Fig. 12—*Argiope simplex*, ♀. *a*, from above; *b*, epigyne; *c*, epigyne from side.
Fig. 13.—*Argiope argyrea*, ♀. *a*, from above; *b*, profile; *c*, epigyne from behind; *d*, epigyne from side.
Fig. 14.—*Acacesia lanceolata*, ♀. *a*, from above; *b*, profile; *c*, epigyne from side.

Maxillae. Dull yellow with broad white edge.

Labium. Narrow deep brown base with broad white triangular tip.

Sternum. Shield-shaped, pointed behind at front edge of c_4, which are about half their width apart. Edges straight or only very slightly concave between coxae.

Legs. 1, 30·6; 2, 27·7; 3, 17·4; 4, 26·8. 1 . 2 . 4 . 3. Spines numerous, but short and weak on all joints.

Palpi. Light yellow with black bristles. ta=2 ti, ti>3 p.

Rio Verde, 6 miles north of Makthlawaiya, running in sand at edge of stream, 22 Oct. 1926.

ARGIOPE ARGYREA, sp. n. (Text-fig. 13.)

This species is nearly allied to *A. argentata* Fabr., which it resembles in both markings and epigyne. The following differences are, however, sufficient to separate it, viz. :—

(1) Clypeus $1\frac{1}{2}\times 1$, as against $3\frac{1}{2}\times 1$.

(2) Eminence of quad. raised rather than depressed in middle.

(3) No tubercle at the dividing line.

(4) General shape of os much longer.

(5) Length of legs 2 . 4 . 1 . 3.

2 ♀: 14·9. Ps. $4{\cdot}4\times 3{\cdot}9$. Os. $10{\cdot}5\times 5{\cdot}0$.
10·1. Ps. $5{\cdot}0\times 4{\cdot}0$. Os. $7{\cdot}0\times 4{\cdot}2$.

The smaller specimen has obviously the os shrunk, but its markings, especially on ps, are the more distinct of the two.

General description.—*Ps.* Light yellow, with broad brown thoracic markings on either side, and slight tinges of red on hinder portion of caput and front of thorax. Sternum light yellow, with broad brown submarginal patches opposite $c_{1.2}$. Legs rather darkened, annulated brown, with f clouded brown above, the lighter portions looking like obscure annulations.

Os. Long and pointed, with spinners about half as far from the apex as from rima. A pair of pointed tubercles pointing upwards and forwards in front (but hardly at corners); another, central, slightly in front of centre; and a pair in longitudinal order on each side rather larger and blunter, the front one a little behind the centre. General colour light yellow. A long, hollow, V-shaped marking with point at apex, red, with a deeper red fluted external boundary-line, with rather obscure light spots on the band opposite the first two flutings. A row of three small impressions just behind the front tubercles, with a pair of slightly deeper ones further back. Sides with irregular dark brown network, which is connected with a lighter longitudinal band from below fore tubercles, and curves up at the end in two branches on to the lateral tubercles. Below, dark brown centre separated by light bands from the side, and behind the spinners a triangular brown network coming to a point at the apex.

The whole, especially ps, covered with prone white hairs, which would, no doubt, in life form a silver covering.

Eyes. Clypeus $<1\frac{1}{2}\times 1$. Normal for genus.

Falces. Light yellow. Teeth U 3, L 3.

Maxillae. Light.

Labium. Dark base with much broader white end.

Palpi. Light, with dark dashes on inner side of p, ti, and ta. Bristles on p, ti, and ta.

Legs. Very difficult to measure, but the order appears to be 2 . 1=4 . 3. 1, 2, 4 are in any case very nearly equal. Spines on all joints numerous, weak, and short.

Nanahua, March 1927.

Genus ACACESIA Sim. (Simon (I), vol. i, p. 795).

ACACESIA LANCEOLATA, sp. n. (Text-fig. 14.)

♀, 7·1.

General description.—Ps. Light yellow, subtriangular, rather pointed in front, the line of edge hardly changing at junction of caput and thorax. Fovea narrow, deep, longitudinal. Striae at caput very distinct. A narrow brown line down centre of caput to fovea. Sternum light yellow with dusky edges. Legs light yellow, but 1 and 2 and ends of $f_{3.4}$ brown-tinged.

Os. Dusky yellow, with black marking at front. A fluted leaf-shape marking covers the greater part of the back, and in centre of this is a spear-shaped marking reaching from the front about three-quarters way to spinners. These markings are outlined by very distinct red lines, but are not of themselves of different colour from the ground. Across the back and the marking are three or four horizontal dusky bands separated by lighter ones. Sides and belly rather lighter, with a dusky longitudinal band down the centre of the latter.

Eyes. Clypeus 2×1. Laterals slightly separated, about $\frac{1}{2}\times2$. Quad. nearly vertical, with long white hairs, equal, broader in front.

I. Slightly proc. from in front. 1 considerably >2. $1.1=2\times1$. $1.2=3\times1$.

II. Strongly rec. from above. $3<1$. $2=4=\frac{1}{2}\times1$. $3.3=\frac{1}{2}\times3$.

Falces. Rather long and pointed, light yellow, with some black hairs.

Teeth. U 4, with 2 and 4 distinctly the stronger. L 2.

Maxillae and *labium.* Light yellow with white. Labium triangular, considerably broader than long.

Palpi. With a pair of short black spines at the end of f. One short basal and long apical on p, and many on ti and ta. $ta>p+ti$. $ti=3\times p$. Claw with about four pectinations.

Legs. 1, 15·9; 2, 14·1; 3, 7·8; 4, 12·0. 1.2.4.3. $m_1+ta_1=p_1+ti_1$; m_2+ta_2 slightly $>p_2+ti_2$; $m_3+ta_3=p_3+ti_3$; $m_4+ta_4<p_4+ti_4$. 3 and 4 considerably weaker than 1 and 2.

Spines: f. 1 basal, 1 pair apical on all.

$p_{1.2}$. 1 apical.

$t_{1.2.3.4}$. About 6, somewhat irregular.

m. Basal pairs and about half a dozen others.

All the spines are moderately strong.

Claws. Paired, about four pectinations at base.

Epigyne. The scape is distinctly turned backwards towards the spinners (see text-fig. 14 *c*), distinguishing this genus from *Eustala*.

Nanahua, March 1927.

Genus EUSTALA Sim. (Simon (I), vol. i, p. 795).

EUSTALA TRIBRACHIATA, sp. n. (Text-fig. 15.)

The general appearance of this spider is that of a *Eustala* (cf. *E.* (*Argiope*) *tridentata* (C. Koch) (9, vol. v, and pl. clvi, figs. 363–4)). Simon distinguishes the genus from *Acacesia* by the forward projection of the scape of the epigyne.

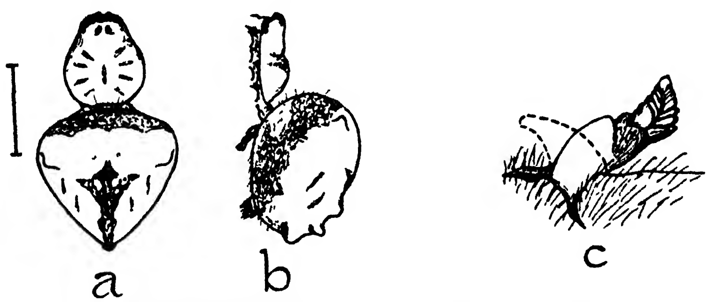
In this specimen (as preserved) it certainly projects backwards, but the organ has the appearance of being abnormally protruded, and, if pushed back to its normal place, it would apparently project forward and, moreover, bear a strong resemblance to Simon's figure 860 (I, vol. i, p. 789) of *E. anastera* Walk. The genus is represented both in Brazil and Paraguay.

♀, 11·6. Ps. 4·8×3·7 ($\frac{2}{3}$). Os. 7·7×7·0 ($\frac{1}{4}$).

General description.—Ps. Light yellow with deep longitudinal fovea and well-marked striae, all brown ; on caput behind eyes a pair of faint longitudinal short brown lines convex towards each other. Sternum light yellow with slight brown shading at edge. Legs light yellow with broad black bands strongest on f, where they occupy the distal three-quarters of the joint.

Os. Light yellow, rhomboidal. The front edge covered by a black marking reaching to shoulders. In centre a black stem proceeds from apex forward to beyond middle, where it branches into a trident. On the edges from level

TEXT-FIG. 15.



Eustala tribrachiata, ♀. *a*, from above ; *b*, profile ; *c*. epigyne from side.

of fork of the trident backwards three short thin black oblique lines. Lower portions of sides black (in continuation of black on front edge) to spinners. Below, light yellow with broad black edge, which joins lateral marking before spinners. The hinder portion of os viewed from the side is nearly at right angles to the back and bends back to the spinners, the black stem of the trident being carried on to the spinners. On this stem are three tubercles, the largest at the top angle, the smallest on the top at front, and the third nearly as large as the first on the hind slope nearer to the apex than to the spinners but further from it than the second tubercle. The shoulders have strong tubercles and the edges between them and the large apical tubercle are fluted—hardly sufficiently, however, to be called tuberculated.

Eyes. Clypeus much >1=quad. Quad. square, convex. Laterals at least a diameter apart.

I. Slightly proc. from above. 1 . 1>1. 1>2.

II. Rec. 3 . 3 nearly 2×3. 2 . 3 . 4 nearly equal.

Falces. Light yellow with red and black ends and sides over basal spot, which is large.

Teeth. U_4, 3 largest; L 4 on one side, 2 on the other.

Maxillae and *labium*. Dark with very broad white tips.

Palpi. Light yellow with a few black spots, of which the largest is on top of femur. ta nearly $2 \times$ ti. ti$>$2 p. Spines on all joints.

Legs. 1, 15·9; 2, 15·0; 3, 9·0; 4, 15·0. 1 . 2=4 . 3.

Sternum. Shield-shaped, fluted edges, and point behind in front of legs 4 . 4, which are adjacent.

Epigyne. The portion shown white in the figure is not chitinized and seems clearly protruded. It will be noted that, if the whole were pushed back so that this were covered, the scape would point forwards towards the pedicel, as shown by the dotted lines in text-fig. 15 *c*, which would satisfy Simon's criterion for the genus.

Nanahua, March 1927.

Genus Araneus (Simon (1), vol. i, p. 829).

Series A.—Without tuberculations.

Araneus nordenskiöldi Tullgr. (13, vol. ii, no. 19, p. 29, pl. iii, fig. 9).

6 ♀: 20·7, 20·4, 20·0, 20·0, 19·2, 17·9.

5 pen. ♂: 13·8, 14·6, 14·7, 14·9, 15·6.

(Tullgren's ♀, 23·5; ♂, 15·5.)

This fine species has been well described and figured by Tullgren from Tatarenda, Bolivia, and hitherto recorded from nowhere else. It appears to be exceedingly common in the Gran Chaco. It is remarkable as an Argiopid with a really poisonous bite. Dr. Carter describes it as 'A poisonous spider from Nanahua. The bite is really serious to the natives. Of this we had definite proof.' In writing of another specimen from Makthlawaiya, he says 'A colonial form the web of which is very strong and a great nuisance in riding across the country as it stretches between palms.'

Tullgren's description only needs amplification with regard to the abdominal markings. These are generally very obscure, but a comparison of all the above specimens leads to the following. A thin white central line, a foliation shown by a thin white fluted border. Sides marked by a large number of nearly vertical brown lines (shown in Tullgren's fig. 9 *a*), imposed on which are three or four broad white lines sloping downwards and backwards separated by brown markings of about the same width. These two systems may be equally developed, especially in the male, but sometimes one is very much more marked, almost to the exclusion of the other. The impression given is of the vertical pattern drawn first and then the sloping on top of it, but both are in the integument itself and not formed by hairs.

In the ♂ the foliation is more distinct and there are dark transverse lines across it; further the front fluting has a pink outer margin and there are three largish pink spots outside the leaf on either side. These can also sometimes be traced in the ♀, but with the pink washed out, as it is also to some extent in some ♂♂.

I can see no trace of the coxal process of the ♂ mentioned by Tullgren, but I have no adult.

Nanahua. ♀ and pen. ♂, 9–15 Feb. 1927.

Makthlawaiya, 15 miles east of. ♀, 13 March 1927. Web very strong between palms.

ARANEUS GREGALIS (Cambr.).

Epeira gregalis Cambridge (10, vol. i, p. 22, pl. v, fig. 3).
Epeira gregalis Keyserling (8, p. 177, pl. ix, fig. 131).
Metazygia gregalis Cambridge (10, vol. ii, p. 501, pl. xlvii, fig. 24).

2 ♀: 6·3, 6·0.

This is distinctly smaller than Keyserling's specimen (8·6), but the description and figure of epigyne by Cambridge seem to leave no doubt. It has been recorded from Brazil.

Campo Grande, 31 Aug. 1926. Stream to south of town.

ARANEUS DELICIOSUS (Keys.).

Epeira deliciosa Keyserling (8, p. 234, pl. ix, fig. 174).

♀, 7·4.

Keyserling's description and figures of this spider, and especially his figure of the epigyne, agree. It has been recorded from Brazil and Paraguay.

Miranda, 6 Sept. 1926.

ARANEUS VERSICOLOR (Keys.).

Cercidia versicolor Keyserling (8, p. 38, pl. ii, fig. 33).

♂. Ps. 3·0×2·4.

Though os is missing, the ps and especially the palpal organ, which is figured by Keyserling and is very distinctive, leave no doubt as to the species. It is recorded from Uruguay.

Nanahua, 5 Feb. 1927.

ARANEUS INEXPLICABILIS, sp. n. (Text-fig. 16.)

A rather distinctive spider, but with os badly damaged.

♀, 8·0. Ps. 2·8×2·2 ($\frac{3}{4}$). Os. 6·0×4·0 (?).

General description.—Ps. Chestnut, smooth ; sternum, coxae, and trochanters dull chestnut ; remainder of legs light yellow with narrow black, very conspicuous bands at terminations of all joints.

Os. As far as can be judged, dull light yellow all over, rounded in front and pointed behind, with pair of short black dashes sloping outwards and backwards in front, three black angular spots on sides near apex, a black dot at apex below, and between this and the spinners a pair of short arcs of contrary curvature and possible further black dots. Spinners, which are little more than halfway from rima to apex, black ; epigyne and operculars dark.

Eyes. Clypeus=1. Quad. slightly longer than broad and slightly wider before. Laterals sessile on common black spot . 2 . 4<4.

I. From before straight by bases, slightly proc. by summits. 1 . 1 nearly 2×1. $2<1$. 1 . 2 about 5×1.

II. Somewhat rec. from above. A tangent to 3 behind touches 2 in front. $3<1$. 4 much <3. 3 . 3=3. 3 . 4 about 6×3.

Falces. Light yellow with a few stiff black hairs on inner edge.

Teeth : U 4, but 1, 2 rudimentary and 4 very much <3.
L 3, 3 largest.

Sternum. Smooth with a pair of upright black hairs on front edge.

Maxillae and *labium*. Chestnut with rather unusually broad white edges.

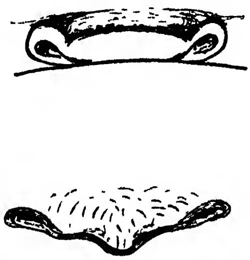
Legs. 1, 8·0 ; 2, 7·0 ; 3, 4·5 ; 4, 7·3. 1 . 4 . 2 . 3.

Epigyne. Simple, but there is a deep hollow in front of the scape which may be an opening.

Spinners. Rather large and strikingly black.

Nanahua, March 1927.

TEXT-FIGS. 16 & 17.



TEXT-FIG. 18.

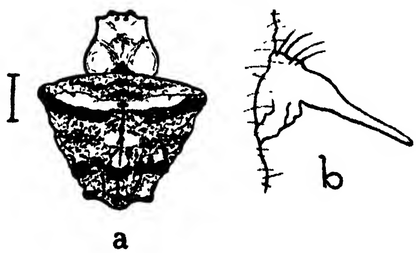


Fig. 16.—*Araneus inexplicabilis*, ♀. Epigyne.
Fig. 17.—*Araneus carteri*, ♀. Epigyne.
Fig. 18.—*Araneus cylicophorus*, ♀. *a*, from above ; *b*, epigyne from side.

Series B.—Tuberculated.

ARANEUS RUGOSUS, sp. n.

Allied to *A*. (*Paramixia*) *guatemalensis* Cambr., recorded from C. America, and *A*. *audax* Blackw., from Paraguay. The distance between the eyes 1 . 1, the epigyne and the belly-markings seem, however, sufficient to distinguish it from the last.

Dr. Carter writes of this specimen : 'It was found sitting immobile, with the legs held tightly round the body, in the centre of its web, which was widely slung between stalks of grass. It looked exactly like a piece of dry twig or stick hanging by a thread, until the web was seen. The resemblance struck me forcibly (in fact, it deceived me at first), and the association of the exposed position and the protective resemblance seemed interesting.'

♀, 6·0. Ps. 3·0×2·2 (¾). Os. 4·6×3·5 (¼).

General description.—*Ps*. Caput light yellow with grey hairs, lateral eye-tubercles prominent, a pair of brown spots nearer thorax than eyes. Thorax

dark brown, thickly covered with white hairs, which obscure it except towards the edges, and a triangle at fovea. Sternum browny yellow with somewhat obscure broad markings at sides. Legs the same, with brown on c and brown annulations.

Os. Subtriangular. Obtusely pointed in front and rounded behind. 13 tubercles. 1 in front central, a large central one behind, and another slightly smaller on edge of hind slope below it, a pair at each shoulder-angle, the upper one the larger, followed on each side by 3 more. Colour dull yellow with an obtuse brown triangle with base between shoulders and apex at front angle followed by brown markings, broadest at centre, with indented edges. Tops of side-tubercles appear as bright yellow dots. Epigaster black except for spiracles which are light. Belly black with a pair of largish white triangles on the outer edges about half-way back.

Eyes. Clypeus nearly 2×1. Quad. square, very slightly broader in front. Laterals on a common tubercle.

I. Straight from in front. $1<2$. $1 . 1=2\times 1$.

II. Rec. from above. $3>1$ and <2. 4 much <2.

Falces. Hairy. Teeth U 3, U 2 much largest. L 2, L 2 distinctly the larger.

Maxillae and *labium*. Dark, white-edged.

Palpus. With long pectinated claw.

Legs. 1, 2 damaged. 3, 5·5; 4, 7·0. f_1 and f_2 distinctly stouter than f_3 and f_4. Spines, a few on u f of $f_{1.2}$.

Corcavada, 3 Aug. 1926. Woods on summit.

ARANEUS CARTERI, sp. n. (Text-fig. 17.)

A very distinct spider of Simon's *A. tabula* group. The general appearance agrees with his figure (I, vol. ii, p. 815, fig. 867), but I cannot reconcile his description.

♀, 12·0. Ps. 4·0×3·9 ($\frac{3}{4}$). Os. 9·6×6·0 ($\frac{1}{2}$). 2 pen. ♂, 10·6 and 10·1.

General description.—Ps. Red-brown with grey hairs, the cephalic striae being rather lighter and in one ♂ a distinct brown dagger-shaped portion on caput (the handle forward between eyes 3 . 3 and the point backwards); in ♀ this shows only as a darker shading. Sternum, etc., light walnut. Legs yellow, very distinctly annulated black.

Os. Pointed in front, very pointed behind, extending well over ps. and much behind spinners. Yellow with black dashes and a black patch at caudal end. A central tubercle in front, 3 pairs of lateral tubercles and a central tubercle behind, which may perhaps be better described as a large conical termination to os behind spinners. Sides as above, but black patches smaller, rounder, and more numerous. Epigaster as sternum. Belly yellow, with a broad black boundary, at sides a square black patch between rima and spinners, another round spinners and behind these, a black central line. Behind this the under portion of the caudal cone is yellow, dotted black.

Eyes. Clypeus slightly >1. A fringe of scanty white hairs. Quad. very

slightly longer than broad, and very slightly broader in front. Laterals on slight common tubercle.

I. Straight from in front by summits, rec. from above. $1>2$. 1.1 slightly >1.

II. Rec. $3.3=1\frac{1}{2}\times 3$. $3>4$. $4<2$. $3<1$.

Falces. Mahogany, with a few white hairs.

Teeth. U 4 with 3 largest, remainder subequal but 1 slightly larger. L 3, subequal but slightly increased from 1 to 3.

Maxillae and *labium.* Dark, light-edged, with labium distinctly longer than broad.

Palpus. Coloured as legs.

Legs. ♀ : 1, 15·2 ; 2, 13·7 ; 3, 8·8 ; 4, 14·7. 1 . 4 . 2 . 3.

♂ : 1, 13·8 ; 2, 12·0 ; 3, 8·0 ; 4, 12·3. 1 . 4 . 2 . 3.

Spines : $f_{1.2}$, 2 or 3 irregular, on distal portion f.

ti, an apical pair 1 on all, and a few more rather irregular on $ti_{1.2}$ l.

All spines are short and often perhaps only bristles.

Sternum. Shield-shaped, a little longer than broad, pointed behind between $c_{4.4}$, which are adjacent.

Epigyne. The scape is a plain fold.

Spinners. Viewed from below, the spinners are above half-way from rima to apex.

Corcavada, 2 Sept. 1926, common in woods.

ARANEUS CYLICOPHORUS, sp. n. (Text-fig. 18.)

Of the *Mahadiva* group of Cambridge (*Verrucosa* of McCook). It is near *A. mexicanus* Lucas (v. Keyserling (8), p. 69, pl. iii, fig. 54, sub *Mahadiva*) and *A. arenatus* Walck. (v. McCook (14), p. 200, pl. xii, figs. 6, 7, sub *Verrucosa*), both of which occur from Mexico to Panama.

♀, 5·8. Ps. $2\cdot 8\times 2\cdot 7$ ($\frac{3}{4}$). Os. $4\cdot 1\times 5\cdot 4$ (front).

General description. Ps. Light yellow with grey hairs, a pair of broad brown markings on the cephalic striae, which are joined over the caput at their fore end by a narrower fainter marking, from the centre of which a still narrower marking goes back to fovea. A deep brown triangle, with apex at fovea and base reaching margin in front of legs 4, covers the base of thorax. Sternum almost black. Legs light yellow with $c_{2.3.4}$ and terminal bands on f (very broad), p, and ti brown ; c_1 much lighter.

Os. Triangle broader than long. In front slightly recurved, with shoulders produced into prominences pointing outwards. A row of three tubercles at hinder surface of top (central longest) and behind these, on vertical hind surface, 4 smaller ones, 2 in centre and a pair between and outside them. Fore surface is dull green dotted white. In front of top surface a broad white procurved band joining the shoulder-tubercles and followed by a white stem, the whole resembling a Greek kylix. This is surrounded by a deep red-brown margin, in the centre of which, above, are 2 white spots. The white stem terminates at the fore-central tubercle, which is red-brown behind, and the

other tubercles are red-brown, more or less surrounded by white. Between the bowl of the kylix and the tubercle-row is a narrow rather obscure brown transverse band passing across the stem, and there are thin lines of the ground-colour down the centre of the stem, enclosing the three central and the hind side-tubercles. Sides have white patches. Belly black with a pair of white spots behind rima.

Eyes. Clypeus$=\frac{1}{2}\times 1$. Quad. as broad as long, much wider before.

I. Rec. from in front. $1<3$, $1.1=2\frac{1}{2}\times 1$, $1.2=4\times 1$.

II. Rec. from above. $3.3=3$, $3.4=5\times 3$, 4 much <3, ≤ 2.

Falces. Light. Teeth U 3, subequal, $1.2<2.3$. L 3.

Maxillae and *labium.* Dark red-brown with light edges.

Legs. 1, 14·4; 2, 10·2; 3, 5·3; 4, 8·7. 1.2.4.3. A pair of short apical spines u on $f_{1.2}$, otherwise only bristles. Legs 3 and 4 notably weaker than 1 and 2.

Miranda, 5 Sept. 1926.

ARANEUS PENTACANTHUS (Walck.).

3 ♀: 8·4, 7·8, 7·3. 2 pen. ♂: 5·0, 4·9. (Measurements to end of posterior median spine.)

Makthlawaiya, 22 Sept. 1926. Very common on surface of swamp.

Nuktetowis, lake 5 miles east of Makthlawaiya, 5 Feb. 1927. Common everywhere on surface of swamps.

Genus GASTERACANTHA Sund. (Simon (I), vol. i, p. 845).

GASTERACANTHA CANCRIFORMIS (L.).

McCook (14), p. 211, and pl. xiv, fig. 9.

♀, 7·5.

Itapura, woods, 19 Aug. 1926.

Genus MICRATHENA Sund. (Simon, I, vol. i, p. 859).

MICRATHENA SILVICOLA, sp. n. (Text-fig. 19.)

♂, 7·4; ps. 3·1; os. 4·5. ♀, 8·1; ps. $3{\cdot}3\times 2{\cdot}0$; os. $5{\cdot}3\times 2{\cdot}0$.

General description.—Ps. Chestnut with small circular fovea. Sternum longer than broad, light. Legs chestnut, but darker on c, ti, and base ot f.

Os. Greeny brown with a large pair of black spines pointing forward at the front angles, a small pair pointing slightly backwards on the edge at the middle, and two large pairs pointing backwards at the hinder upper and lower corners. Down the centre a pair of lines formed of white dots close together and meeting at about two-thirds back and including at the centre and near the end two pairs of larger white circular spots surrounded with red, the white lines much fainter before the fore and behind the hind pair of dots. Immediately behind the fore pairs of white spots an adjacent pair of red ones, and in front and just outside the white lines a fainter pair of red dots. On each side at the fore angle in front of the spine a white dot and an irregular line of white dashes from

front to near end in the line of spines. Immediately inside these lines rows of faint red spots. Below, black except on epigaster and central prominence. The spinners on a very large tubercle, which appears in centre of os as viewed from below, and in front of this the smaller central prominence. Markings are not all shown on the figure.

Eyes. Clypeus$=1\frac{1}{2}\times 1$. Quad. about as broad as long, slightly narrower before.

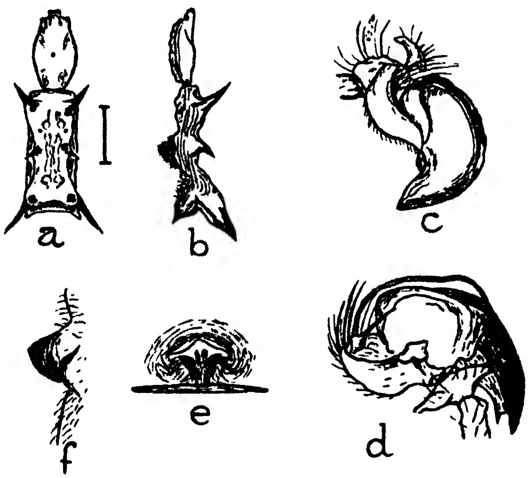
I. Rec. from in front. $1=2$.

II. Strongly rec. from above. 4 much <2. $3=2\times 1$.

Quad. on a prominence. Laterals subadjacent.

Teeth. U 4, of which the last very small. L 3.

TEXT-FIG. 19.



TEXT-FIGS. 20 & 21.

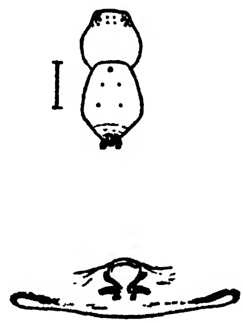


Fig. 19.—*Micrathena silvicola.* *a*, ♀, from above; *b*, profile; *c*, ♂, left palpus from below; *d*, ♂, right palpus from above; *e*, ♀, epigyne from below; *f*, ♀, epigyne from side.

Fig. 20.—*Misumena viridis*, ♀. From above.

Fig. 21.—*Misumena pulchra.* Epigyne.

Maxillae and *labium*. Normal for the family.

Legs. 1, 8·8; 2, 8·1; 3, 5·1; 4, 10·0. 4.1.2.3. No spines, a few stiff bristles, hardly spines, on f, p.

Epigyne. Simple in front, very prominent from the side.

♂. Differs from the female by absence of the central white and red markings on os.

Palpus. p short with a long erect dorsal bristle, ti has a narrow stalk, spreading out into an enormously broad cross-piece at right angles, this may be considered as a long sharply pointed hypophysis provided with long erect bristles on one side, and at the other end in front a broad blunt one.

ta is small, cup-shaped, a mere cap to the organs which are very large.

Makthlawaiya, 8 April 1927. In woods.

Family THOMISIDAE.

Subfamily Misumeninae.

Genus Misumena Latr. (Simon (I), vol. i, p. 1025).

Misumena viridis, sp. n. (Text-fig. 20.)

♀, 6·1. Ps. 3·3×3·1 ($\frac{3}{3}$). Os. 3·5×2·9 ($\frac{3}{3}$).

General description.—*Ps.* Light yellow clypeus, round and between eyes, and a shield-shaped central broad band reaching from eyes to fovea; the fore part of this band is very slightly darker and has in its centre a short, thin, nearly white, longitudinal stripe backwards from eyes 3. Lateral bands considerably darker. Sternum and legs light.

Os. Pentagonal with sharp angles, cretaceous above except terminal triangle immediately above spinners, which, with sides, is yellow. 5 muscle-spots, very distinct. Epigaster yellow with brown on either side on stigmata. Belly cretaceous with a double row of dots down centre.

This is described as a green spider when alive.

Eyes. Clypeus <than quad. with a few long, widely separated, and forwardly directed hairs. Eyes subequal, but 3 very slightly smallest and perhaps 2 very slightly largest. White markings round all, but large and confluent on the tubercle of 2 . 4.

Legs. 1, 12·6; 2, 12·6; 3, 6·4; 4, 7·0. 1=2 . 4 . 3.

Spines: f_1 4 basal u and 1 or 2 more u. $f_{2.3.4}$ 1 or 2 u.
ti_1 5 pairs l, ti_2 2 pairs l.
$m_{1.2}$ 7 pairs l.

The specimen is hardly mature, the epigyne showing as two dots only.

Itapura, 22 Sept. 1926. Woods.

Misumena ignobilis, sp. n.

pen ♂, 3·0.

General description.—*Ps.* Uniform lightish yellow with several long black upright hairs or bristles, but with the white marks, on which the eyes stand, large, forming a single band covering eyes 4 . 2 . 1 and meeting in centre so as to form a large chevron, the white of eyes 3 also extended forward and inwards and almost meeting to form a second chevron inside the former. Sternum and legs light, the latter with obscure reddish bands at ends of ti and m.

Os. Greyish green with milky cretaceous spots bounding it and forming a narrow V at hinder end, which is continued as spots forward. Sides cretaceous. Belly greyish-green with lighter epigaster.

Legs. Damaged, but proportions about as last, 2 seems, however, definitely longer than 1.

Spines. f as $f_{2.4}$ of *M. viridis*; ti 2 pairs, m 2 pairs, but very weak and hardly more than bristles.

The os is rather less angular at the sides than the last, but its general appearance is not unlike.

Nanahua, 5 Feb. 1927.

MISUMENA PULCHRA, sp. n. (Text-fig. 21.)

♀, 6·0.

General description.—Ps. Light yellow with a narrowish red band on either side, the two meeting with a rather fainter red through the eye-space, the central marking is left very broad between these bands with a faint tinge of red in front, on which is a faint short longitudinal stripe of white ; outside the bands the light is considerably broader than they. No white about eyes. Sternum light. Legs light, the anterior banded with red at the end of f, on p and beginning of ti, and at end of ti and m, of which last the band covers more than half.

Os. Light all over above and below. Above, there is, on each side of front half, a narrow dusky edging, and, on hinder half, a pair of rows of obscure dusky spots tending to meet above the spinners.

Eyes. Clypeus $<$quad. Quad. slightly broader than long.

I. Recurved. Eyes equidistant, 1 considerably <2. $1=3$.

II. Slightly recurved. 3 . 3 v. slightly $>3\,.\,4$. 3 slightly <4, which is much <2.

2 and 4 on a common but not very marked tubercle.

Falces, etc. A few long erect hairs on falces, clypeus, and ps.

Legs. 1, 10·4 ; 2, 10·6 ; 3, 5·2 ; 4, 6·1.

Spines. ti_1 l 4 pairs with a 5th in 1 row, ti_2 l 4 pairs, $ti_{3.4}$ u 1 . 1 weak, $m_{1.2}$ l 6 pairs.

Epigyne. Light centre with red surrounds (see text-fig. 21).

Nanahua, March 1927.

Family PLATORIDAE.

Genus VECTIUS Sim. (Simon (1), vol. ii, p. 19).

VECTIUS NIGER Sim. (Text-fig. 22.)

♀. Simon (*Plator niger*) (4), p. 236.
♂. Tullgren (10), p. 40, pl. vi, fig. 16.
Simon (1), vol. ii, p. 17, figs. 14, 15.

♂, 4·7. Pen. ♂, 4·9. ♀ : 8·0, 6·1, 6·0, 6·0, 6·0, 5·4. Imm. : 4·9, 3·0.

I give a figure of the epigyne, which, as far as I know, has not been figured before. To Simon's description of this part I would add that the hinder dark portion is cleft for some little distance behind the point of the V. The depression behind the eyes that he refers to appears to me to be very slight.

Miranda, 6 Sept. 1926, adult ♀.

Nanahua, 5 Feb. and 10 March 1927 : imm. and pen. ♂.

Rio Verde, Makthlawaiya, 19 May 1927 : adult ♂ and ♀.

Family CTENIDAE.

Subfamily ACANTHEINAE.

Genus NOTHROCTENUS, gen. nov.

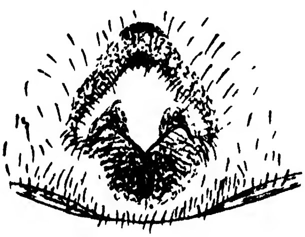
NOTHROCTENUS STUPIDUS, sp. n. (Text-fig. 23.)

This seems to be separated from *Phymatoctenus* by the spines on the anterior legs and the general appearance.

Imm. ♀, 8·8. Ps. 3·9×3·0 ($\frac{2}{3}$). Os. 5·5×3·8 ($\frac{2}{3}$)×3·8 ($\frac{1}{2}$).

General description.—Ps. Somewhat agalenid-like. Central marking light yellow, covering the whole caput behind the eyes, pinched between caput and

TEXT-FIG. 22.



TEXT-FIG. 23.

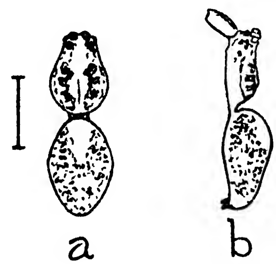


Fig. 22.—*Vectius niger* Sim. Epigyne.
Fig. 23.—*Nothroctenus stupidus*, ♀. *a*, from above ; *b*, profile.

thorax, swelling round fovea and narrowed slightly to base ; on either side of caput it has a pair of very small dark markings (the fore round, the hind long) and some more obscure ones in centre. Lateral markings dark brown, broad but interrupted by a broken yellow band ; margin light yellow, rather broad. Face has a thick black strip down centre, on either side a light yellow strip, and outside again at corners another strip of the same colour as the lateral marking. Fovea deep and long. Striae well defined. Sternum light, as broad as long. Legs light, splashed greeny-brown on femora and ringed on ti and m.

Os. Grey-brown with black dots. On fore half a longitudinal light central mark. Below, light.

Eyes. Clypeus=1. 1 . 1=1. 2<1. 2 . 3< 2 . 1. Row 2 . 3 . 3 . 2 slightly proc. by fore edges (from before). Quad. 1 . 3 . 3 . 1 about as broad as long and narrower before. 4 slightly >3. 3=2×1. 3 . 3=$\frac{1}{2}$. 3. 3 . 4=1$\frac{1}{2}$×3. Row 4 . 3 . 3 . 4 strongly recurved.

Simon's figure (I, vol. ii, p. 120, fig. A) of *Anahita fauna* is a good representation of the eyes, except that 4 is too small.

Falces. Light with a broad dark band down the centre and a narrower at the sides. Basal spot long and strong.

Teeth. U 3, of which 2 much the strongest. L 3, slightly decreased from 1 to 3. All subequally spaced.

Maxillae. Light edges very slightly, if at all, hollowed on outer edge towards base.

Labium. Light, as broad as long or very slightly longer, notched on outer edge near base, not longer than $\frac{1}{2}$ max.

Legs. All detached and 3 missing, but certainly 1 and 2 have ti 7 pairs below (and one of them a few at sides) and m 4 pairs below and possibly a small apical pair in addition. These spines are long and prone. All femora have a few moderately long spines above. Claws 2 rather long, curved, and slender, with 2 or 3 small teeth in centre. Claw-tufts well developed, but not concealing the claws.

Spinners. 1 . 3 . 3 . 1 form a square. 1 . 1 being the stouter, marked by a black patch and separated by at least their diameter. 3 . 3 about the same length, but slenderer. 2 . 2 smaller and nearer 3 than 1.

Nanahua, March 1927.

Family CLUBIONIDAE.

Subfamily Liocraninae.

Genus Syrisca Sim. (Simon (1), vol. ii, p. 131).

Syrisca agalenoides, sp. n. (Text-fig. 24.)

Imm. 6·7. Ps. $2{\cdot}6 \times 1{\cdot}8$ ($\frac{2}{3}$). Os. $3{\cdot}7 \times 2{\cdot}0$ ($\frac{1}{2}$). Imm. 5·0.

This species resembles *S.* (*Teminius*) *braziliana* Keyserling (4, p. 40), but is not, I think, identical.

General description.—Has the general appearance of an agalenid.

Ps. Dark brown with a broad central band from eyes to base, the sides of which are parallel except at base where the band narrows rapidly; just at commencement of narrowing are a pair of slight encroachments on the ground. Fovea longish, narrow. Striae very faint. Sternum light, nearly round and terminating in front of legs 4, which are adjacent. Legs light, with dark longitudinal shadings above, which are most marked in the small specimen.

Os. Dark with a broad light strip down the centre, on which are two longitudinal lines of dark dots, and at the end dark chevrons rather broken. Sides light, with lines of oblique dark blotches behind. Belly and epigaster light. The small specimen is darker with the light markings traceable, but not prominent.

Eyes. Clypeus $< \frac{1}{2} \times 1$. Quad. 1 . 3 slightly longer than broad and slightly narrower before.

I. Straight. Eyes close, subequal but 1 . 1 slightly $>$1 . 2.

II. Slightly proc., subequal. 3 . 3 v. slightly $<$3 . 4. 3 . 4=4.

Eyes 3 and 4 slightly >1 and 2. 2 and 4 on same dark marking (or prominence ?), but 2 . 4>½×4.

Falces. Parallel, swollen at base, light with dark shading in front and on outer edge.

Teeth. U 3, 2 much the larger (1 is broken off, but, I think, was undoubtedly present). L 2.

Maxillae. Light, broader at centre (where palp is inserted) than apex.

Labium. Light, slightly longer than broad.

Legs : 1, c 1·0, tr+f 2·0, p+ti 2·5, m+ta 2·1. 7·6.
2, c–f 2·6, p+ti 2·0, m+ta 2·0. 6·6.
3, c–f 2·2, p–ta 3·2. 5·5.
4, c–f 3·2, p–ta 5·1. 8·3.
} 4 . 1 . 2 . 3.

Text-fig. 24. Text-fig. 25. Text-fig. 26.

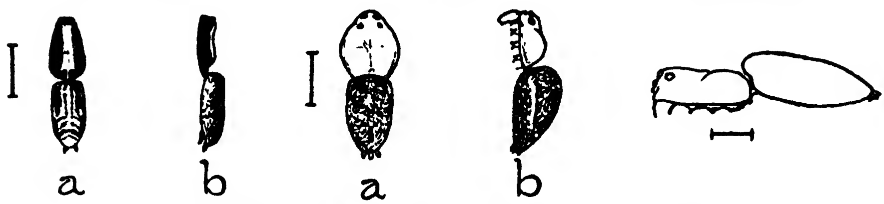


Fig. 24.—*Syrisca agalenoides*, imm. *a*, from above ; *b*, profile.
Fig. 25.—*Dyrinoides onychiatus*, imm. *a*, from above ; *b*, profile.
Fig. 26.—*Dossenus marginellus*, ♂. Profile.

Claws 2, pectinated. Light scapulae on $ta_{1.2}$ and $m_{1.2}$ and still slighter on $ta_{3.4}$. Claw-tufts of a few hairs only on all legs, leaving claws bare, however. Trichobothria on ta, m, ti.

Spines : On 1, 2, only 1 or 2 on f.
3 . 4, rather heavily, but irregularly spined on ti, m, and some on f.

Spinners. Superior has second joint long, conical, and >½ first, which is itself as long as inferior spinner. The arrangement is almost like that of *Tegenaria*.

Nanahua, March 1927.

Family PISAURIDAE.

Genus Dyrinoides, gen. nov.

Dyrinoides onychiatus, sp. n. (Text-fig. 25.)

Imm., 7·0. Ps. 3·0×2·9(⅝)×1·9(¾). Os. 4·0×2·6(½)×2·8(⅓).

This species is distinguished from *Thaumasia* by the spacing of L teeth and the shape of the labium, from *Dyrines* by the presence of small apical pair of spines on $ti_{1.2}$ and eyes distinctly procurved. From both and from Simon's whole group Dolomedeae (Petrunkevitsch's Thaumasiinae) by the presence of an onychium.

General description.—Ps. Yellowish with narrow margin of white hairs from eyes 2 to base. In front of short longitudinal fovea, a triangle defined by the foremost of two foremost thoracic striae and the base of the caput, all other striae very faint. Slopes forward slightly and backward steeply from highest point. Sternum and legs much the same colour as above, the former with some obscure dark dots.

Os. Dark greenish with yellow band along sides and very obscure central longitudinal mark in front, with three or four pairs of dots outside and two short transverse lines following above spinners, all very obscure. Belly same colour as above, but without spots.

Eyes. Clypeus $>2\times1$.

I. Proc. 2 much <1, $1.1>1.2$, almost adjacent. I distinctly >3.3 (externally).

II. Strongly rec. $3=4=2\times1$.

Falces. Rather strong, light, with strong basal spot.

Teeth. U 3, order of size 2 . 1 . 3, last being very small. 1 . 2 much >2.3.
L 3, with possibly a very minute fourth. Order 1 . 2 . 3, evenly spaced.

Labium. Light, slightly broader than long and $<\frac{1}{2}$ maxilla.

Legs. 1, 11·5; 2, 11·9; 3, 10·6; 4, 12·0. 4 . 2 . 1 . 3.

Spines: All f have several above at sides and apex, strongest on posterior.
All p have 1 long u apical.
$ti_{1.2}$. 3 long pairs and another at apex l, others at sides and above.
$ti_{3.4}$. Fewer and more irregular, but equally long.
$m_{1.2}$. 2 long pairs l, a few smaller at sides and u.
$m_{3.4}$. About the same number, but irregular.

No scopulae. Teeth of paired claws about 8. Onychium present.

Miranda, 6 Sept. 1926, surface of water in woods near river.

DYRINOIDES MINUTUS, sp. n.

Imm. Ps. $1·9\times1·6$ ($\frac{4}{5}$). Os. $1·9\times1·2$ ($\frac{1}{2}$).

It is quite possible that this may be a young specimen of *D. onychiatus*. They were found in more or less the same country and both running on water. There is no difference between them that may not be attributable to age.

General description.—Ps. Yellowish with very broad lighter lateral bands covered with white hairs; on the hinder edge of each of these bands a pair of dark circles. Shape as *D. onychiatus*.

Os. Dark greenish with light central marking, on either side of which are 3 or 4 distinct white dots. Sides lighter, but hardly forming a distinct light band as in last.

Eyes. Clypeus slightly $<2\times1$.

I. Slightly proc. 1 much >2. $1.1>1.2$, but all close. $1>3.3$.

II. Strongly rec. $3=4=2\times1$.

Quad. 1 . 3 slightly broader than long and slightly narrower before.

Falces. Light with basal spot. Teeth U 3, L 3.

Labium. Breadth $\gtreqless$ length.

Legs. 3, 4·7 ; 4, 6·0, remainder loose.

Spines. Most of the legs being loose, it is impossible to be certain, but they may be all f u 1 . 1 . 3 ap., all p u 1 ap, $ti_{1.2}$ l 3 prs. (no apical)+some smaller at sides, $t_{3.4}$ about the same but more irregular, $m_{1.2}$ l 3 prs. (or 2 l and 1 lat.) and others at sides, $m_{3.4}$ about the same but more irregular.

Onychium small. No scapula.

Campo Grande, 2 Sept. 1926, stream to east of town, running on surface of water.

Genus Dossenus Sim. (Simon (I), vol. ii, p. 314).

Dossenus marginellus, sp. n. (Text-fig. 26.)

Pen. ♂, 5·7. Ps. 2·5×2·0 ($\frac{4}{5}$). Os. 3·6×2·0 ($\frac{5}{9}$).

This specimen is very near *D. marginatus* Sim., which has been recorded from Matto Grosso. Cambridge's drawings (II, pl. xiv, figs. 1, 3) of ♀ exactly agree as to eyes and markings, except that he does not distinguish a narrow white boundary between the light side and dark fluted centre of the os. His note (p. 155) on the extreme length of the spines is borne out by this specimen. Unfortunately the specimen is not adult and a comparison of the palpal organs is impossible. I feel bound to describe it as a new species. Simon's description (2, p. 19) only deals with markings and genital organs.

General description.—Ps. Dark chestnut centre, with parallel sides from face to base, the width just including the eyes. Outside this a broad light band with white hairs. Eyes on black spots. Sternum light with scattered black spots. Legs chestnut with strong black under ti and distal end of f.

Os. A central band of same width and colour as ps, with edges parallel but fluted, especially at end, where it narrows to spinners. There is an obscure dark central marking in centre front of this band, and its edge is finely red. It is bounded by a distinct narrow white line following the flutings, and the sides below are rather lighter than the band and sprinkled with reddish dots. Belly light with dark smudges and bounded at bottom of sides by a row of light dots.

Eyes. Clypeus >2×1.

I. Slightly rec. 1 . 1>1. 1=nearly 2×2.

II. 3 . 3 (outside)>1. 3 . 3 nearly 2×3. 3>2×1 . 4>3. (v. Cambridge (II), vol. i, pl. xiv, fig. 5.)

Falces. Light, but darker in front carrying on central band of ps.

Teeth. U 3. L 3.

Maxillae. Light with darker shadings especially on outer side.

Labium. Slightly broader than long, <$\frac{1}{2}$ max. Shaded except at apex.

Legs. So many have been detached that relative measurements cannot be given. They are rather long and are distinguished by very long spines,

probably 3 prs. on ti and 4 prs. on m. On one of the last the basal pair is so long as almost to reach vertex.

Under the claws is a tuft of about six spatuliform hairs, and there is a small onychium.

Itapura, 19 Aug. 1926.

Family LYCOSIDAE.

Genus LYCOSA Latr.

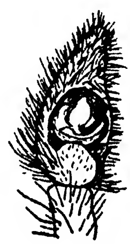
LYCOSA NANAHUENSIS, sp. n. (Text-fig. 27.)

♀, 11·7. Ps. 5·7×4·5 ($\frac{2}{3}$). Os. 6·0×4·0 ($\frac{2}{3}$).

This species has some resemblance to *L. nordenskioldi* Tullgr. (13, p. 61), recorded from Bolivia, but is much smaller with differences of coloration, and the epigyne of Tullgren's figure, though of the same type, is hardly the same.

TEXT-FIG. 27.

TEXT-FIG. 28.



TEXT-FIG. 29.

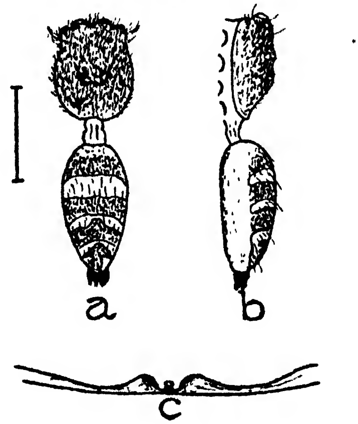


Fig. 27.—*Lycosa nanahuensis*, ♀. Epigyne.
Fig. 28.—*Lycosa albimarginata*, ♂. Left palpus from below.
Fig. 29.—*Psecas splendidus*, ♀. *a*, from above; *b*, profile; c, epigyne and rima.

General description.—Ps. Central band light and increasing rapidly from base to in front of fovea, where it is notched and broadens abruptly; sides parallel to outside eyes 4, where it decreases abruptly to pass within eye-square and terminates squarely before reaching eyes 3. All in front of fovea is much obscured by the ground-colour. Lateral bands, light but with patches of ground-colour, extend, though much broken by the ground, below eyes to clypeus. Fovea long, narrow, dark. Sternum dark with light rim and somewhat obscure light centre. Legs light with somewhat obscure banding, most noticeable on $f_{1.2}$ and on the whole of 3 and 4.

Os. Dark with light speckling, especially at sides. Sides and below light with fine speckling; between rima and spinners a very dark patch.

Eyes. Clypeus=1. Quad. broader than long, narrower in front.
I. Straight or slightly proc. 1=nearly 2×2. 1 . 1=$\frac{1}{3}$×1>1 . 2, which=$\frac{1}{3}$×2.
II. Distinctly >I. 3=2×1. 3 . 3 slightly <3.
III. 4 slightly <3.
Falces. Teeth, U 3, L 3.
Maxillae. Light.
Labium. Very slightly longer than broad. Dark at base.
Legs. 1, 16·7 ; 2, 16·0 ; 3, 15·2 ; 4, 20·1. 4 . 1 . 2 . 3. m_4<p+ti.
Scapulae on all ta and on distal portions of $m_{1.2}$.
Spines : $f_{1.2.3}$ u 5+3 ap, f_4 u 3+3 ap.
p_1 f 1, $p_{2.3.4}$ f 1 h 1.
ti_1 $l_{2.2.2}$ f 1 . 1, ti_2 l 1 . 1 . 2 u 1 . 1 ap, ti_3 l 2 . 2 . 2, ti_4 l 5+2 ap u 3·1.
m_1 l 2 . 2 . 1, f 1 ap, m_2 l 2 . 2 . 1 u 1, $m_{3.4}$ l 2 . 2 . 2 u 2 . 2 . 2.
Many of the spines are irregularly paired and it is often difficult to decide between laterals and uppers.

Paired claws have about seven teeth.

Epigyne. See text-fig. 27.

Nanahua, March 1927.

LYCOSA ALBIMARGINATA, sp. n. (Text-fig. 28.)

♂, 9·9. Ps. 6·6×4·1. Os. 4·5×3·0.

General description.—Ps. Dark chestnut, becoming black on caput. Central marking of white hairs very narrow between eyes 3, broadening slightly behind eyes 4, and narrowing gradually to its termination just behind fovea. Submarginal bands of white hairs broadish behind and narrowing slightly to termination at about eyes 4. Black rim. Sternum light. Legs light without annulation, but slightly shaded above.

Os. Nearly black with very obscure central marking in front, on either side of which a very obscure line of white hairs followed by blotches. Sides with very bright lines of white hairs not meeting in front and nearly but not quite meeting above spinners. Below, dark with slightly darker obscure blotches in front and around spinners.

A very distinct spider, the white borders to ps and os and the white central line on ps striking the eye at once.

Eyes. Clypeus=2×1, with fringe of dark hairs.

I<II. 1>2. 3 . 3>3. Quad. narrower in front and about as broad behind as long.

Falces. Rather long and narrow, dark. Teeth, U 3, with 2 largest, L 3, about equal, 3 level with $U_{1.2}$.

Labium. Longer than broad, darker than maxillae.

Palpi. f dark, curved and with a few spines above. p and ti light with white hairs. ta dark with some white hairs. ta>ti, ti>p.

Legs. 1, 16·9 ; 2, 16·3 ; 3, 16·3 ; 4, 20·2. 4 . 1 . 2=3.

$m_{1.2}$ slightly <2×ta. m_3=2×ta. m_4>2×ta. p+ti on one leg<p+ti on the other. Paired claws have seven teeth.

Spines : f_1 3+2 ap, $f_{2.3}$ 5+3 ap, f_4 2+3 ap.
All p 1 f 1 h.
$ti_{1.2}$ l 2 . 2 f 1 . 1 h 1 . 1.
$ti_{3.4}$ l 2 . 2 . 2 ap, f 1 . 1 h 1 . 1 u 1 . 1.
All m l 2 . 2 . 3 ap, f 1 . 1 . 1 ap, h 1 . 1 . 1 ap.

All spines are rather irregularly placed, the apical ones on m form a definite verticilla and the others on m and even on ti may perhaps be considered as such. Spines generally are longer on posterior legs. All legs are lightly covered with long upright hairs with crooked ends, and the ta below with thicker and shorter ones, which on 1 may almost be considered to form a scapula.

Nuktetowis, lake 5 miles east of Makthlawaiya. On weed on surface of swamp. Carries eggs on back of abdomen. 5 Feb. 1927.

Family SALTICIDAE.

Division *PLURIDENTATI*.

Subfamily THIODININAE.

Genus PSECAS C. Koch. 1850.

PSECAS SPLENDIDA, sp. n. (Text-fig. 29.)

2 ♀, 12·5, 10·0.

This species is nearly allied to *P.* (*Thiania*) *sumptuosa* figured by C. Koch (9, vol. xiii, p. 172, Tab. ccclx, fig. 1224).

To Simon's description of the genus (1, vol. ii, pp. 471 & 1050, sub *Epinga*) add :—

General description.—*Ps.* Dark with grey hairs. *Os.* Golden with grey hairs with broad transverse brilliant red stripes, scattered long and short black hairs over the whole. Sternum dull yellow, belly and sides grey with darker centre to the former. Legs dull yellow banded dark brown in 2 . 3 . 4 ; 1 much the stoutest and with ti and m dark brown ; 2 stouter than 3 and 4.

Teeth. U 2, 1 much the stronger.
L 4, evenly spaced and 1 the strongest, decreasing to 4.

Labium. Twice as long as broad.

Sternum. More than twice as long as broad. Front truncation $\frac{1}{2}$ width of labium and interval between $c_{1.1} < \frac{1}{2}$ c_1. Pointed behind and $c_{4.4}$ subadjacent.

Measurements. Total length 12·5. Ps. 5·0×3·5×1·9. Os 6·4×3·0×2·8.

Legs. 1 . 4 . 2=3. 1, 11·7 ; 2, 8·9 ; 3, 8·8 ; 4, 11·0.

Spines : f. Several above especially on 1 and 2.
p. 1 small f.
ti. On 1 . 2, 5 prs. (3 below and others at sides). Middle pair longest. On 3 . 4 1 below, 2 pairs at sides.
$m_{1.2}$ l 2 . 2 1st, about middle, much longest.
m_3. l 1 . 2, u 2 . 2, m_4. l 2, f 1.

Ps. has black hairs strongest at sides developing into tufts outside eyes 2 and fringes on clypeus and above eye-row I.

Epigyne. Is shown in text-fig. 29 *c*, but is probably not fully developed.

Makthlawaiya, 8 April 1927.

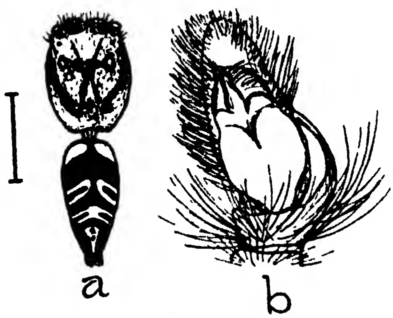
PSECAS PULCHRA, sp. n. (Text-fig. 30.)

♂, 11·2.

General description.—Ps. Black, thickly strewn with white hairs, which form a broad edging behind and at hinder portion of sides, though margin itself is black. Os has a ground covered with grey hairs, on which are broad transverse black stripes ; below, grey with centre enclosed with dark grey V. Sternum and coxae dark chestnut. Legs very dark, except for lighter patellae.

Teeth. U 2, 1 largest ; L 4, at least 1 and 2 united at base, decreasing from 1 to 4.

TEXT-FIG. 30.



TEXT-FIG. 31.

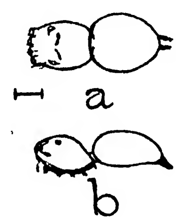


Fig. 30.—*Psecas pulcher*, ♂. *a*, from above ; *b*, left palpus from below.
Fig. 31.—*Sitticus brutus*, imm. *a*, from above ; *b*, profile.

Palpi with long black hairs. Ti has a long black process on outer edge pointing forward and close to the bulb, reaching to near its extremity. Style thick and pointing directly forward.

Labium and *Sternum* as in *P. splendida*.

Measurements. Ps. 5·1×4·0. Os. 6·0×2·8.

Legs. 1 . 4 . 2 . 3. 1, c–t 10·7, m+ta 4·1=14·8 ; 2, 11·0 ; 3, 9·5 ; 4, 12·3. 1 is much longer, but not so definitely stronger than the rest, as in *P. splendida*.

Spines : ti_1. 6 pairs (perhaps 3 l and 3 lateral).
ti_2. 1 . 1 . 2, and 2 lateral pairs.
$ti_{3.4}$. About 4 pairs l and lateral.
$m_{1.2}$. 2 . 2, the f of each pair in 1 much the longest.
$m_{3.4}$. 2 verticillae.
$p_{1.2}$. Small spine f. I cannot detect it on 3 and 4.
f. All have spines above, $f_{1.2}$ a few f near apex.

Makthlawaiya, 8 April 1927.

Division *Unidentati*.

Subfamily Sitticinae.

Genus Sitticus Sim. (Simon (I), vol. ii, p. 581).

Sitticus brutus, sp. n. (Text-fig. 31.)

2 imm., 3·4. Ps. 1·9. Os. 2·0, 2·8.

This species only differs from the genus *Sitticus* as defined by Simon by the eye 3 being unquestionably slightly nearer 4 than 2, but this hardly seems sufficient reason to institute a new genus.

General description.—Ps. Brown, legs light yellow banded brown. Sternum light. *Os.* Slightly lighter brown with a very obscure double row of whitish spots down centre line, and a row of similar but slightly more marked spots on each side. In the smaller specimen these appear as 3 pairs of light spots (of which the first and last are large) down centre, followed by three cross-bars above spinners and the lateral spots as indentations of the dark dorsum by the lighter sides. Belly and epigaster dark.

Eyes. Clypeus about $\frac{1}{2} \times 1$ with thick white hairs. I straight by summits. 3 . 4 slightly $<$3 . 2. Quad. length$=\frac{3}{4}$ breadth, slightly narrower behind.

Falces. Teeth U 3, L 0 (like Simon (I), vol. ii, fig. 699 A, p. 579, *S. pubescens*).

Legs. Not measurable, but 4 unquestionably much $>$3.

Nanahua, March 1927.

Genus Camponia, gen. nov.

Camponia lineata, sp. n. (Text-fig. 32.)

♂, 7·0. Ps. 3·9$\times$3·0. Os. 3·9$\times$2·4.

General description.—Ps. Very dark with obscure marking formed by white hairs between eyes and in a triangle to base of thorax. A lateral marginal band narrowing from behind towards leg 2, where it terminates. Above leg 3 another broader band starts and passes round to clypeus. Sternum dark, legs rather lighter, banded dark especially 1. Os has a light yellowish ground, on which is a broad central dark band stepped about middle, then narrower and ending in dark chevrons above spinners. Thin lateral dark bands hardly visible from above. Dark epigaster and belly with dark triangular marking, apex at spinners.

Ps. Shallow with caput nearly as large as thorax. A rather large depression behind the eyes, followed by a faint longitudinal stria.

Eyes. Clypeus very narrow with thick white hairs. I straight, 3 . 4 slightly $<$3 . 2. Quad. parallel, about half thorax, eyes 4 on slight rises (hardly to be called prominences).

Falces. Parallel with a belt of long white hairs sloping outwards and forwards from junction; ridged below. Unguis long and slender. Outer ridge high and prominent; no inner ridge. Teeth U 2, 1, at angle, the stronger, L 0, but there is a knob which in some lights looks like an incipient tooth.

Maxillae have a tooth-like process on the outer edge.

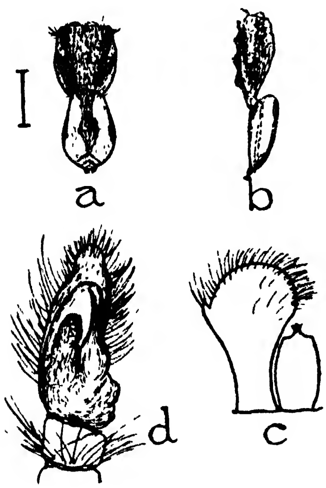
Labium about twice as long as broad, rather pointed.

Palpi have long white hairs, especially on f and inner side of ti. Ti about the same length as p, somewhat triangular from above, with a strong thorn-like upright process on outer edge below.

Legs. 1 very much stronger than 3, 4, and somewhat stronger than 2, especially f, which is arched above. 1, 8·2 ; 2, 7·2 ; 3, 6·9 ; 4, 8·1. 1=4 . 2 . 3. $p+ti_4$ much $>p+ti_3$. m_1 about $2\times ta_1<ti_1$.

Some long white hairs on all legs, especially strong on inner side of apical end of f and on p.

Text-fig. 32.



Text-fig. 33.

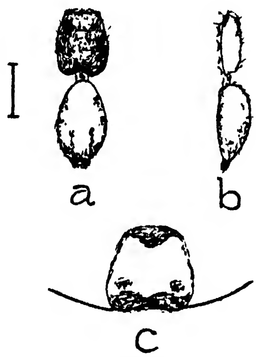


Fig. 32.—*Camponia lineata*, ♂. *a*, from above ; *b*, profile ; *c*, maxilla and labium ; *d*, right palpus from below and slightly from outer side.

Fig. 33.—*Breda quinquedentata*, ♀. *a*, from above ; *b*, profile ; *c*, epigyne.

Spines : f_1 none, $f_{3.4}$ a few towards apical end above, strongest on 3.
p none.
ti_1 l 3 or 4 pairs (last apical), $ti_{3.4}$ h 1, l an apical pair.
$m_{1.2}$ l 2 . 2, $m_{3.4}$ fragments only remaining, on which is visible a weak apical verticilla, and on one a basal lateral spine.

All the legs are much damaged. ti, has 4 spines below on f side and 3 on h, those on h are much the shorter.

Sternum. Much longer than broad, narrowly truncated in front but $c_{1.1}$ nearly as wide apart as labium.

It seems impossible to put this species anywhere except in Petrunkevitch's subfam. Sitticinae and Simon's group Salticeae, but the nearest existing genus appears to be *Menemerus* (Marpissinae).

Campo Grande, 2 Sept. 1926. A note in the tube states ' 2 smallest running on the surface of the water '. This note probably refers to this species.

Subfamily Marpissinae.

Genus Breda Peck. (Simon (1), vol. ii, p. 608.)

Breda quinquedentata, sp. n. (Text-fig. 33.)

♀ 7·0. Ps. 3·0×2·2. Os. 4·0×2·5.

General description.—Ps. Dark mahogany, sternum darker, legs light but heavily banded dark.

Os. Pale brown with obscure dark brown blotches or spots at sides of and across hinder portion, sides lighter, belly rather dark. (The markings are damaged.)

Eyes. Clypeus narrow with scanty long black hairs. Eyes of I are moderately well separated (hardly subcontiguous as described for genus). Quad., breadth : length : : 5 : 3. 2 . 3 very slightly <3 . 4.

Falces. Teeth U 5, L 1. L tooth is close to base and hard to see, but is at least as strong as strongest U.

Labium. Nearly twice as broad as long.

Sternum. Front truncation=½ width labium, but $c_{1.1}$ are wide apart as labium.

$$\textit{Legs}: \left.\begin{array}{llll} 1, & \text{c–ti } 5{\cdot}0\,; & \text{m+ta} & 1{\cdot}3=6{\cdot}3. \\ 2, & \quad ,, \ 4{\cdot}3\,; & \quad ,, & 1{\cdot}2=5{\cdot}5. \\ 3, & \quad ,, \ 4{\cdot}1\,; & \quad ,, & 1{\cdot}6=5{\cdot}7. \\ 4, & \quad ,, \ 5{\cdot}9\,; & \quad ,, & 1{\cdot}9=7{\cdot}8. \end{array}\right\} 4 \,.\, 1 \,.\, 3 \,.\, 2.$$

$p+ti_3<p+ti_4$.

1 is very much stronger than the other legs, its c being twice the size of the rest. 2 distinctly stouter than 3, 4, but c shorter. 3, 4 about equally strong.

Spines : m_1 2 pairs very short and stumpy, ti_1 1 (and perhaps a second).
m_2 2 pairs (none on ti).
$m_{3.4}$, an apical verticilla, $ti_{3.4}$ 1 . 1 . 2.
All f have long curved bristles.

Epigyne. See text-fig. 33*c*.

Makthlawaiya, in woods, 8 April 1927.

Subfamily Plexippinae.

Genus Plexippus C. Koch, 1850 (Simon (1), vol. ii, p. 734).

Plexippus paykulli (Audouin). (Text-fig. 34.)

Koch (9), vol. xiii, p. 107, and figs. 1168, 9, sub *P. ligo*.
Simon (1), vol. ii, p. 712, figs. 839–41, A–C.

2 specs. ♂, 8·0. Ps. 4·3×3·1. Os. 4·0×2·9. Legs 10·9, 9·5, 9·5, 10·5. 1 . 4 . 2=3.

Imm., 7·0. Legs : 7·4, 7·2, 8·0, 8·5.

Simon's figure of the ♂ palp leaves no doubt of the identification. The species is cosmopolitan, and has previously been recorded from Guiana and Paraguay.

Campo Grande, 17 Sept. 1926, stream to east of town. A note 'Two smallest running on the surface of the water' may refer to the smaller of these two specimens, but more probably to *Camponia lineata*.

PLEXIPPUS ALBICRINITUS, sp. n. (Text-fig. 35.)

1 spec. ♂, 7·8. Ps. 3·9×2·1×2·6. Os. 4·0×2·4.

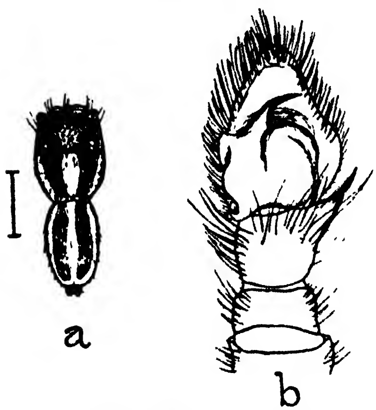
Legs: 9·5, 9·2, 8·7, 9·0. 1 . 2 . 4 . 3.

This species nearly resembles *P. paykulli*. The markings are much the same, but the legs are all much more nearly of equal length, and 2 is slightly >4.

General description.—Ps. Very dark mahogany with a broad central white stripe formed by white hairs and reaching from eyes 1 to base; submarginal broad similar white bands stopping in front about the level of eyes 4; legs mahogany lined black especially on 1 and 2; sternum light.

Os. Light longitudinal band whole length of dorsum, bordered by dark bands of about the same width; sides light; belly and epigaster dark.

TEXT-FIG. 34.



TEXT-FIG. 35.

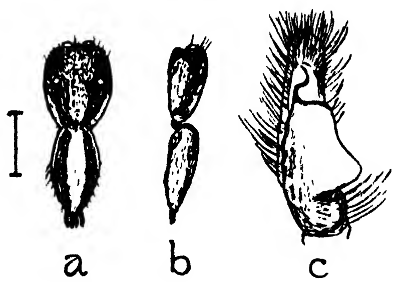


Fig. 34.—*Plexippus paykulli* Aud., ♀. *a* from above; *b*, left palpus from below.
Fig. 35.—*Plexippus albicrinitus*, ♂. *a*, from above; *b*, profile; *c*, right palpus from below.

Eyes. Clypeus has some long white hairs, about $\frac{1}{4}$×eye 1.

Falces. Long white hairs in front.

Legs at first glance look rather ringed black than striped, but the black never completely circles the joints; there are long white hairs on femora below, strongest on 3, 4.

Palp. f has a spine near vertex, p has two long black hairs in series above, ti<p and on one side so short that ta looks a continuation of p, ta has long black hairs, all joints have white hairs. Ti terminates on the outer side closely applied to the bulb by a short dark slightly bifurcated apophysis (not visible in the figure), which is liable to be missed except in a good light. For bulb, see text-fig. 35 *c*.

The following are the chief characteristics distinguishing this species from the last :—

(1) The central band on ps. is formed of white hairs only, the ground beneath, when they are rubbed off, being as dark as the rest of the ground.

(2) The lateral white band stops below eyes 4 instead of reaching the fore edge of ps.

(3) Leg 2 is definitely longer than 3.

(4) Palpus.

Nanahua, 15 March 1927.

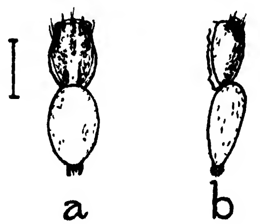
PLEXIPPUS LUTEUS, sp. n. (Text-fig. 36.)

Imm. 7·0. Ps. 3·0×2·3×1·6. Os. 4·2×2·9×2·7.

The specimen is considerably damaged, but there seems to be no adequate reason for separating it from the genus.

General description.—*Ps.* has a light chestnut central band from fore eyes to spinners, divided by dark strips from the broad, much lighter, submarginal bands and dark marginal line, sternum light, legs light with dark shadings.

TEXT-FIG. 36.



TEXT-FIG. 37.

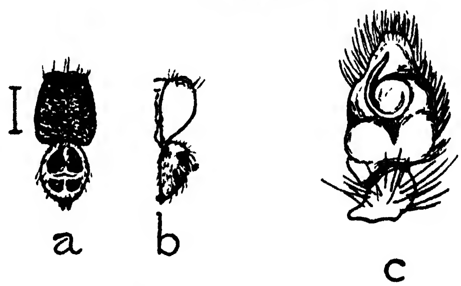


Fig. 36.—*Plexippus luteus*, imm. *a*, from above ; *b*, profile.
Fig. 37.—*Makthalia cincta*, ♂. *a*, from above ; *b*, profile ; *c*, left palpus from below.

Os. Light centre, bounded by rather obscure dark edges ; sides, epigaster, and belly light. The markings except for colour much as in *P. albicrinitus*.

Eyes. Clypeus narrow with long white hairs. I rec. 3 . 2=3 . 4.

Falces. Teeth U 2, 1>2, L 1, strong and pointed.

Labium considerably longer than broad.

Sternum truncated in front, distinctly wider than labium.

Thoracic stria short and narrow, follows a small transverse depression between eyes 4 . 4, from which a pair of striae radiate backwards.

Legs. Not measurable, but 4 is almost certainly slightly >3. 1 and 2 are very slightly stronger than 3 and 4, but the difference is barely appreciable.

Spines agree with generic description ; the inner spine on p_1 is undoubted.

Nanahua, March 1927.

Genus Makthalia, gen. nov.

Makthalia cincta. sp. n. (Text-fig. 37.)

♂, 5·7.

This species has affinities with *Plexippus*, from which it is distinguished by the teeth and armature of the legs. It must, I think, be placed in a new genus.

General description.—Ps. Black with white hairs on caput and a broad submarginal band of white hairs. Sternum dark. Legs slightly lighter, heavily banded dark especially on femora.

Os. Black with a light surround on front, sides, and rear, and a broad white band concave forwards slightly behind the centre. On each of the dark bands so left a short narrow longitudinal central line, the hinder narrowest and lightest. Belly dark with obscure dusky markings.

Eyes. Clypeus wider than $\frac{1}{2}\times 1$. I recurved. $3 . 2 \overset{=}{\gtrless} 3 . 4$. Quad. with breadth : length$=3:2$.

Falces subtriangular, with a short unguis thick at base and occupying most of the end of the paturon. Teeth, U 0, L 1, very minute with possibly a still more minute one at some distance.

Labium. Length=about $1\frac{1}{2}\times$breadth. Subtriangular and rounded at the end.

Legs. 1, 6·0; 2, 6·0; 3, 6·9; 4, 6·8. Measurements difficult, and it can only be said that 1 and 2 are approximately equal, as are 3 and 4. $1=2$. $3=4$. $p+ti_3 \nless p+ti_4$.

f_1 distinctly swollen and 1 and 2 rather stronger than 3 and 4.

$ti_{1.2.3}$ are covered with thick black bristles below, stronger in 1 and 2 than 3 and wanting in 4.

Spines : $f_{1.2.3.4}$ u 1 . 1 very long, with a shorter bunch at top apex, slightly on the inner side.

$p_{2.3.4}$ a lateral spine on each side ; on p_1 I can only verify one.

ti_1 l 2 . 2 . 2 (last apical).

ti_2 l 1, f 1 . 1, h 1 . 1.

ti_3 l 2 apical, f 1 . 1 . 1, h 1 . 1 . 1 .

ti_4 l 1 . 2 (last apical), f 1 . 1 . 1, h 1 . 1 . 1, u 1 basal.

$m_{1.2}$ l 2 . 2.

$m_{3.4}$ 2 verticillae, the basal very irregular.

Sternum. Longer than broad, round pointed behind between $c_{4.4}$ which are adjacent, truncated in front about middle of lab., $c_{1.1}$ wide apart.

Thorax has a thin longitudinal stria behind a transverse depression level with eyes 4.

Palpus. $ti<p$ with a flat process on the outer side ending in a toothed edge.

Makthlawaiya, 8 April 1927. In woods.

Division *Fissidentati*.

Subfamily Maeviinae.

Genus Rudra Peckham, 1885.

Rudra baurensis, sp. n. (Text-fig. 38.)

Imm., 5·0.

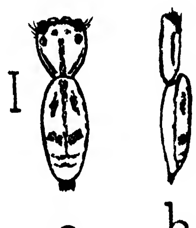
To Simon's description of the genus add :—

General description.—*Ps.* Very low and flat, yellow with a dark longitudinal central stripe from base to just behind eyes, and a narrow submarginal band separated from the dark margin by a light strip. Front legs very strong, dull yellow with brown patches, remaining legs light yellow.

Os. Light yellow with a central dark stripe, paired spots in front and transverse stripes behind. Sternum and all below light yellow.

Eyes. I straight by summits. Quad. at least twice as broad as long and parallel. 3 . 2=3 . 4. 2 small but slightly >4. Clypeus almost nil with thin white hairs.

Text-fig. 38.



Text-fig. 39.

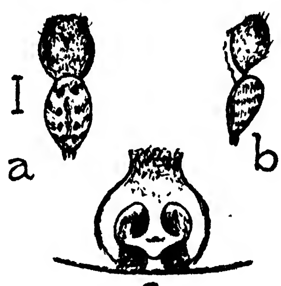


Fig. 38.—*Rudra baurensis*, imm. *a*, from above ; *b*, profile.
Fig. 39.—*Mirandia australis*, ♀. *a*, from above ; *b*, profile ; *c*, epigyne.

Falces. Yellow with black front. Teeth, U 2, L 1, cleft and resembling Simon's fig. E, 998 (I, vol. ii, p. 846).

Measurements. Ps. 2·3×1·8×0·7.
Os. 3·2×1·6×1·0.

Legs : 1,	c–f 2·1,	p+ti 1·9 ;	m+ta	1·2=5·2.	} 1 . 4=2 . 3.
2,	c–ti,	3·0 ;	,,	0·9=3·9.	
3,	,,	2·4 ;	,,	1·0=3·4.	
4,	,,	3·0 ;	,,	1·0=4·0.	

Leg 1 has a broad brown marking on the inner side of f and another smaller one behind towards the apex ; on the basal part of the former as seen from above are some white racquet-shaped hairs which are very distinctive. The other

joints also have dark markings near the apices. The whole leg with its spines is exactly as Simon's figure 1003, C (*R. polita* Peckham).

Palpi. Yellow with dark splashes above all joints. Ta slightly >ti>p. There is no claw.

Ps. has a pair of dark spots in centre of quad.

Os. The central line is the lightest, running with an irregular boundary from front to second cross-line. The front pair of spots are large and somewhat the shape of a bird flying. The first band is broad and somewhat irregular; the 2nd and 3rd bands are much narrower with wings concave forward.

Baurú, 12 Aug. 1926.

Subfamily CYTAEINAE.

Genus MIRANDIA, gen. nov.

MIRANDIA AUSTRALIS, sp. n. (Text-fig. 39.)

♀, 4·5. Ps. 2·1 × 2·0. Os. 2·3 × 1·8.

This species answers the requirements of Petrunkevitch's Cytaeinae, and may possibly be placed in Simon's group Belleineae, but I cannot find any known genus into which it fits. It has some resemblance to *Hasarius*, but the relative lengths of legs 3 and 4 exclude this.

General description.—Ps. Deep chestnut, nearly as high and broad as long.

Os. Yellow-brown with a whitish cross-bar in front and four pairs of black spots down centre, each spot bordered with white on the inner side; sternum dark, heart-shaped; belly very light with a dark line up the centre from spinners to epigaster and a pair of shorter dark lines diverging from spinners forwards; legs light, ringed mahogany at ends of joints (especially f_1).

Eyes. I very slightly rec. by summits. 3 . 2 distinctly <3 . 4. Quad. much broader than long and parallel or very slightly broader behind. Clypeus narrow with white fringe.

Falces. Triangular from side, white hairs in front. Teeth, U 2, rather wide apart, L 1, cleft, with 2nd cusp very slightly >1st.

Palpi. Light yellow with long white hairs on f and ta, and dark spots above on p, ti, ta. ta>ti>p.

Labium considerably longer than broad, at least ⅔ maxilla.

Legs. Not measurable, but probably 1 . 4 . 2=3; 4 is undoubtedly >3. 1 (of which only f remains) is much the strongest, with f slightly swollen; 2 distinctly stronger than 3 and 4. Spines on all f, a few short on p, ti, and m of 3 and 4. These joints are missing on 1 and 2.

Sternum. Longer than broad, truncated in front, leaving $c_{1.1}$ about as wide as base of labium. Round point behind in front of $c_{4.4}$, which are subcontiguous.

Epigyne. See text-fig. 39 *c*.

Miranda. Surface of water of pool in woods near river. 6 Sept. 1926.

SOLIFUGAE.

Family SOLPUGIDAE.

Subfamily DAESIINAE.

Genus MUMMUCIA E. Sim. 1879, Ann. Soc. Ent. Fr. ser. 5, vol. ix.

MUMMUCIA DUBIA, sp. n.

Gervais (15), p. 15, Arach. t. 1. f. 2 (*Galeodes*) (1849).
Simon (3), p. 151, t. 3. ff. 29, 30 (1879).
Kraepelin, 'Das Thierreich' (16), Lief. 12, p. 116, f. 86.

This species only differs from *M. variegata* Gerv. by colouring, and quite possibly, when further specimens are available, may prove to be the same.

Falces. Olive with three white longitudinal stripes meeting at the fore end and white edges.

Ps. Olive with three pairs of white transverse wedges, strongest and most irregular on first segment.

Os. Broad central and somewhat narrower lateral longitudinal stripes on back separated by white stripes ; sides white with black dots ; belly greyish olive.

Palpi. Brown.

Legs. Somewhat lighter with a hint of longitudinal grey markings above f and ti on 2, 3, and 4.

Nanahua, 10 March 1927.

REFERENCES TO LITERATURE.

(1) SIMON, E. 1892. 'Histoire naturelle des Araignées', 2e ed. Paris
(2) ——. 1898. Ann. Soc. Entom. Belg. xlii. 'Descriptions d'Arachnides nouveaux des familles des Agelenidae, Pisauridae, Lycosidae et Oxyopidae.
(3) ——. 1879. Ann. Soc. Entom. France, (5) ix. 'Essai d'une classification des Galéodes . . .'
(4) ——. 1880. Ann. Soc. Linn. Bordeaux, xxxiv. 'Revision de la famille des Sparassidae'.
(5) ——. 1897. Proc. Zool. Soc. London. 'On the Spiders of the Island of St. Vincent.—Part III.'
(6) KEYSERLING, Graf E. 1884, 1886. 'Die Spinnen Amerikas', vol. ii. Theridiidae.
(7) ——. 1891. 'Die Spinnen Amerikas', vol. iii. Brazilianische Spinnen.
(8) ——. 1892. 'Die Spinnen Amerikas', vol. iv. Epeiridae.
(9) KOCH, C. 1836–8. 'Die Arachniden'.
(10) CAMBRIDGE, F. O. PICKARD. 1889–1905. 'Biologia Centrali-Americana, Zoology', vols. i & ii. Arachnida Araneidea.
(11) ——. 1903. Proc. Zool. Soc. London, vol. i. 'On some new Species of Spiders belonging to the Families Pisauridae and Senoculidae . . .'
(12) TACZANOWSKI, L. 1872. Horae Soc. Entom. Ross. 'Les Araignéides de la Guyane Française'.
(13) TULLGREN, A. 1905. Arch. Zool. ii. 'Araneida from the Swedish Expedition through the Gran Chaco and the Cordilleras'.
(14) McCOOK, H. C. 1893. 'American Spiders and their Spinning Work', vol. iii.
(15) GERVAIS, P. 1849. Gay's 'History of Chili, Zoologia.—Anoplura', vol. iv.
(16) KRAEPELIN, K. 1901. 'Das Tierreich', Palpigradi und Solifugae.

The circulation of blood in the air-breathing chambers of *Ophiocephalus punctatus* Bloch.

By S. H. LELE, The Royal Institute of Science, Bombay. (Communicated by Dr. S. L. HORA, F.L.S.)

(With 4 Text-figures)

[Read 22 October 1931]

THE snake-headed fishes of the genus *Ophiocephalus* have attracted the attention of naturalists and zoologists for a very long time on account of their habit of temporarily leaving their aqueous homes and of going on excursions over surrounding marshy lands. This unusual behaviour is rendered possible by the possession of special air-breathing organs in addition to the gills. Max Rauther in 'Die Akzessorischen Atmungsorgane der Knochenfische' (Ergebnisse u. Fortschritte d. Zool. vol. ii, 1910) has described in detail the air-breathing organs of *O. striatus*, and B. K. Das in 'The Bionomics of certain Air-breathing Fishes of India, together with an Account of the Development of their Air-breathing Organs' (Phil. Trans. Roy. Soc. Lond. B, vol. ccxvi, 1928) has dealt with the structure and development of air-breathing organs in 'Snake-headed' Fishes. In both these papers the network of capillary blood-vessels in the walls of the air-chambers has been described and illustrated. As, however, the conditions observed in *Ophiocephalus punctatus* differ in certain salient features from those described by these authors, it has been thought advisable to give a description of the circulation of blood in its air-chambers.

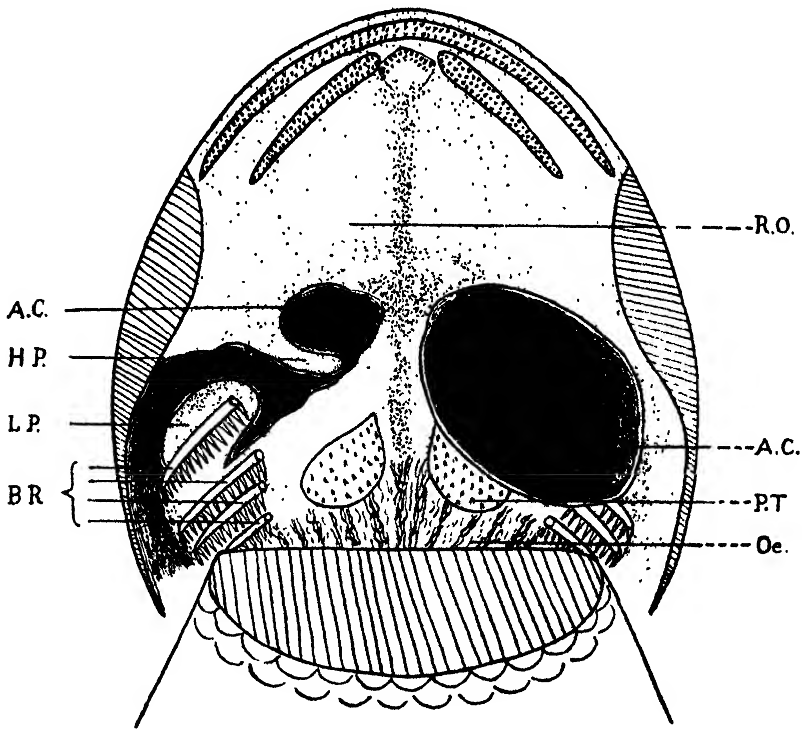
STRUCTURE OF AIR-CHAMBER

There are two air-chambers, one on each side of the auditory region of the skull. When the lower jaw, with part of the gills, is removed, each of them is seen as a deep pit in the roof of the mouth, lying between the first gill-arch and the hyomandibular (text-fig. 1, *A.C.*). It is a spacious cavity, extending posteriorly to the last pharyngeal cleft and communicating freely with the mouth-cavity on the one side and the gill-chamber on the other side. When exposed from the side (text-fig. 2), it has an oval outline and is seen to lie between the roof of the pharynx and the thin roofing bones of the skull. As the cavities have enlarged, the auditory region of the skull appears to have been compressed between them.

In order to increase the respiratory area two processes from the surrounding bones project into the air-chamber. The hyomandibular process (text-fig. 1, *H.P.*) is in the form of a thick, short, vertical plate, passing obliquely inwards and

backwards. The second process arises from the epibranchial of the first gill-arch (text-fig. 1, *L.P.*), and has the form of a thin broad plate lying between the hyomandibular process and the outer wall of the air-chamber. This epibranchial plate is homologous with the labyrinthine organ of *Anabas*, and may be termed the labyrinthine plate. The epibranchial of the second gill-arch also has a shelf-like projection in front. Similarly, there is a lateral flap

TEXT-FIG. 1.



Ventral view of the air-chambers of *O. punctatus*, as seen on removal of the lower half of the head with the ventral halves of the branchial arches on the right side and with the surrounding parts on the left side so as to expose the whole of the left air-chamber (diagrammatic).

A.C., air-chamber; *B.R.*, branchial arches; *H.P.*, hyomandibular process; *L.P.*, labyrinthine plate of the first epibranchial; *Oe.*, oesophagus; *P.T.*, pharyngeal teeth; *R.O.*, roof of the oral cavity.

from the narrow base of the brain-case. These two latter processes join to form the floor of the air-chamber and conceal most of its posterior part in a ventral view.

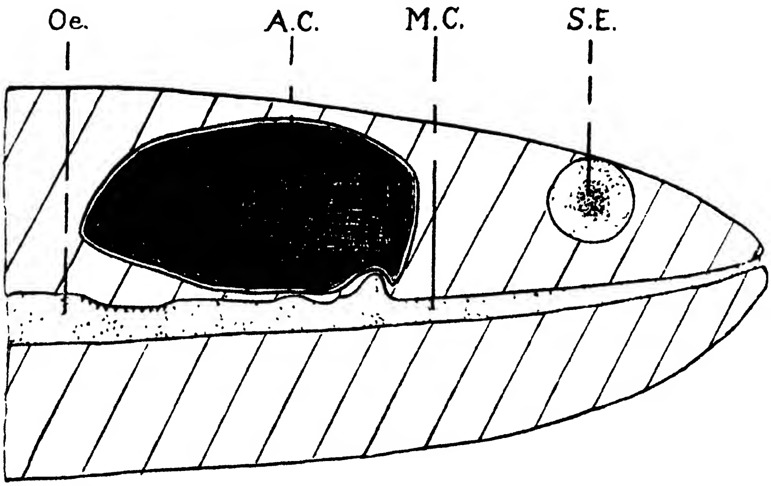
The air-chamber is lined by a thin, richly vascular epithelium, which is continuous with the mucous membrane of the mouth-cavity and with the inner

lining of the gill-chamber. Its superficial layer is smooth, except at the posterior end of the chamber. Between the epithelial membrane and the surrounding bony capsule there is a thick layer of loose connective tissue which contains the large and small blood-vessels with their innumerable finer branches. The subjacent connective tissue is so loose that the epithelial wall very easily comes away from the surrounding bones and the muscles which lie around its posterior parts.

Capillaries

The epithelial membrane is relatively thick and composed of many layers of cells towards the inner side and posterior end of the air-chamber, and also where it covers the epibranchial and hyomandibular processes. It contains

Text-fig. 2.



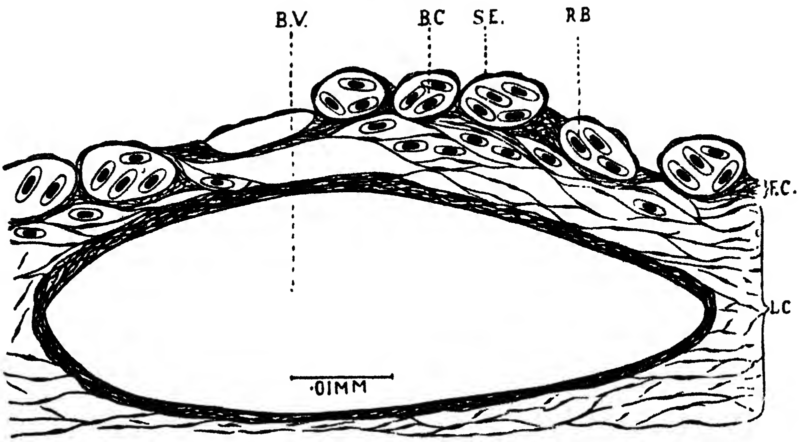
Lateral view of the air-chamber of *O. punctatus* exposed by completely removing lateral parts of the body (diagrammatic).

A.C., air-chamber ; *M.C.*, mouth-cavity ; *Oe.*, oesophagus ; *S.E.*, socket of the eye.

numerous mucous glands, and is richly supplied with blood-capillaries. The branches of the subjacent blood-capillaries reach the surface in the form of loops and tufts passing through the layer of epithelial cells, as described and illustrated by Rauther in *O. striatus* and by Das in *O. punctatus*. The dorsal and outer sides of the air-chamber have a relatively thin membrane, which has been said to be ' practically non-vascular ', but sections treated with Mallory's connective tissue stain show it to be highly vascularized. Here the epithelium is reduced to a single layer of squamous cells (text-fig. 3, *S.E.*), and is stretched by the protruding blood-capillaries. The capillaries (*B.C.*) are large, and appear at first sight to be only resting on the surface of the lining of the air-chamber ; they are so numerous, and their network so close-meshed,

that in section a continuous series of these transversely cut capillaries is usually seen. Their connections with the underlying vessels are often indicated by blood-corpuscles situated obliquely in the thin intervening tissue. This layer of connective tissue is fibrous and is underlaid by a very loose connective tissue with large intercellular spaces. The large blood-vessels come to the surface of the latter tissue and form a noticeable layer of large and small blood-vessels immediately below the thin fibrous layer. The blood-vessels are lined with numerous pigment-cells and can be easily seen. The single layer of flattened epithelial cells, with the underlying capillary network, is analogous to the respiratory wall of the alveoli or air-sacs in the lungs of land vertebrates.

TEXT-FIG. 3.



Section of the superficial respiratory layer of the wall of the air-chamber of *O. punctatus* (diagrammatic).

B.C., blood-capillary; *B.V.*, blood-vessel; *F.C.*, fibrous connective tissue; *L.C.*, loose connective tissue; *R.B.*, red blood-corpuscles; *S.E.*, squamous epithelium.

BLOOD CIRCULATION

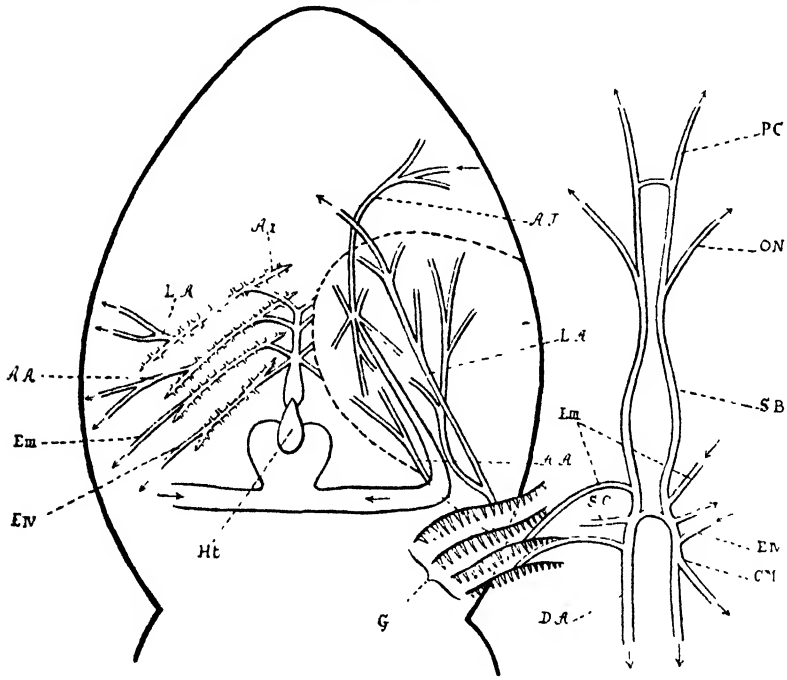
The capillaries of the air-chamber are ultimately connected with the 1st and 2nd afferent branchial arteries on the one side and with the anterior jugular vein on the other. The 1st afferent branchial artery (text-fig. 4, *A.* I), besides giving branches to its gill-filaments, is continued as a large labyrinthine artery (*L.A.*), passing to the anterior end of the air-chamber across the labyrinthine plate of the 1st epibranchial. This artery, after emerging from the gill, gives off a large branch, and both it and this branch give off smaller branches. The 2nd afferent artery is similarly continued beyond the gill (*A.A.*). It divides into two, each of which branches out on the surface of the posterior part of the wall of the air-chamber. The efferent arteries of the 1st and 2nd gills break up into numerous small branches in the wall of the air-chamber.

The capillaries of the air-chamber drain into the tributaries of the anterior jugular vein (text-fig. 4, *A.J.*). The latter thus returns to the heart the deoxy-

genated blood from the anterior part of the body, and also the oxygenated blood from the first two gills and the air-chamber. Thus it is seen that the first two gills of each side do not directly supply oxygenated blood to the rest of the body through the dorsal aorta, as is usually the case in fishes.

On the 3rd and 4th efferent branchial arteries (text-fig. 4, *E.* III, *E.* IV) join the supra-branchial artery (*S.B.*) of their side. Further these efferent branchial arteries are found to be in direct communication with the afferent branchials of these two gills. After giving branches to the gill-filaments,

TEXT-FIG. 4.



Blood-vessels of the air-chamber and branchial arterial system of *O. punctatus* (diagrammatic).

A. I, first afferent branchial artery; *A.A.*, air-chamber artery arising from the second afferent artery; *A.J.*, anterior jugular vein; *C.M.*, coeliaco-mesenteric artery; *D.A.*, dorsal aorta; *E.* III & IV, third and fourth efferent branchial arteries; *G.*, gills; *Ht.*, heart; *L.A.*, labyrinthine artery; *O.N.*, orbito-nasal artery; *P.C.*, posterior carotid artery; *S.B.*, supra-branchial artery; *S.C.*, subclavian artery.

they continue as large vessels to join the supra-branchial of their side. Thus the 3rd and 4th branchial arteries now form two arterial arches, and take most of the blood passing through them directly to the central arterial system without oxygenation in the branchial filaments of these two gills, which are relatively very small. The blood which flows to them from the two arches appears to be distributed, after oxygenation, to the neighbouring parts.

The 3rd efferent branchial joins the supra-branchial of its side in front of the transverse commissural vessel joining the two supra-branchials. The supra-branchial of the left side, after giving off the left subclavian artery (*S.C.*) and being joined by the 4th efferent branchial (*E.* IV), is continued posteriorly as the dorsal aorta (*D.A.*). Similarly, after giving off the right subclavian artery and after being joined by the 4th arterial arch, the right supra-branchial is continued as the coeliaco-mesenteric artery which soon divides into two large vessels. Anteriorly both the supra-branchials receive the orbito-nasal (*O.N.*) and posterior carotid arteries (*P.C.*) of their sides.

Remarks

Rauther has observed in *O. striatus* that the first two afferent branchial arteries exhaust themselves in giving off branches to the filaments of the first two gills, and that the arteries of the air-chamber are branches from the efferent branchial arteries of these two gills. Das has shown that the air-chambers of the Ophiocephalid fishes develop as pockets of the pharynx. Putting these two facts together, it appears that in *O. striatus*, although the pharyngeal epithelium has increased and bulged out, and has taken on the respiratory function, its vascularization is not greatly modified, since a supply from the efferent branchials might be expected in an organ in this position. In *O. punctatus*, however, the arteries of the air-chamber start directly from the afferent branchial arteries, and thus it appears that the vascularization of its chambers is more efficient and more advanced than in *O. striatus* so far as aerial respiration is concerned. This is so because the blood-stream does not pass through the capillaries of the gills before going to the air-chamber. The branches of the efferent branchials of the first two gills that supply blood to the air-chambers in *O. punctatus* may be regarded mainly as nutrient arteries of the walls of the air-chambers.

From the modifications of the branchial arteries noted above and from the fact that the fish dies when deprived of access to atmospheric oxygen (Das, op. cit. p. 205, Experiment *e*), it is evident that its air-chambers play an important part in the respiration of the fish. It is also clear that the blood oxygenated in the air-chambers is mixed with the venous blood from the rest of the body, the resulting mixture being then supplied to the body as arterial or oxygenated blood.

This investigation was carried out partly at the Royal Institute of Science, Bombay, and partly in the Department of Oceanography, University of Liverpool. My best thanks are due to Prof. P. R. Awati, Bombay, and Prof. J. Johnstone, Liverpool.

Reports of an Expedition to Paraguay and Brazil in 1926–7, supported by the Trustees of the Percy Sladen Memorial Fund and the Executive Committee of the Carnegie Trust for the Universities of Scotland.

Fresh-water Nematoda from the Paraguayan Chaco.* By Dr. Hans A. Kreis,

Zoological Department of the University of Basel, Switzerland.

(With 11 Text-figures.)

[Read 14 April 1932.]

Towards the end of 1928 the Zoological Department of the University of Basel received a number of samples of plankton collected by Dr. G. S. Carter in Paraguay. It was intended that only the Cladocera should be identified, but the author also separated the Nematoda which were present. These specimens are the subject of the present paper. The systematic list given below shows that 365 specimens belonging to this group were found, divided among ten genera and nineteen species. The following genus and species are new :—

1. Genus *Enoplochilus*.
2. Species : (a) *Aphanolaimus duodecim-papillatus*.
   (b) *Trilobus parvipapillatus*.
   (c) *Enoplochilus obtusicaudatus*.
   (d) *Dorylaimus paraguayensis*.
   (e) *Dorylaimus homalopapillatus*.

A paper describing the nematodes of Paraguay has been written by v. Daday (7). His descriptions are very imperfect and superficial, and they contain so many mistakes that they are almost worthless, but, as the paper has been written, it is better to try to extract the few good facts from his descriptions than to disregard the paper. This course will be followed.

The fact must be emphasized that these nematodes, although found in hauls taken immediately below the surface of water, must have been brought into that position by the act of hauling or by some other disturbance. They are not truly planktonic, and, in confirmation of this, the results show that where vegetation was present the worms were much more numerous.

The accurate adaptation of the species to the biological conditions is also evident. The swamps and pools in which the worms were found sometimes

* I am much indebted to Miss Rowena Ratcliffe, Dep. of Agriculture, Washington, D.C., for her help in the translation of this paper into English.

dry completely during droughts, and many species (e.g. *Actinolaimus tripapillatus*, *Trilobus diversipapillatus*, species of *Dorylaimus* such as *D. homalopapillatus*, and the representatives of the *filiformis* group) develop a large number of thick-shelled eggs. The best example of this is *Actinolaimus tripapillatus*. I have described its development in a separate paper (Kreis, 10).

In addition to lacustrine species such as these, there are also terrestrial forms in the samples, i.e. species which live in soil impregnated with water (e.g. *Rhabdolaimus terrestris*, *Achromadora tenax*, and *Dorylaimus filiformis* f. typ. sf. *attenuatus*). These representatives of the group must not be taken to be true fresh-water forms.

Systematic list.

Species.	♀$_e$.	♀.	(♀).	♂.	(♂).	j.	Total.
1. *Aphanolaimus duodecim-papillatus*, sp. n.	..	..	..	1	..	..	1
2. *Monhystera paludicola* de Man	1	..	..	2	..	1	4
3. —— *annulifera* v. Daday	..	1	..	..	..	..	1
4. *Trilobus diversipapillatus* v. Daday	28	1	6	13	..	10	58
5. —— *parvipapillatus*, sp. n.	1	3	1	1	..	7	13
6. *Plectus paraguayensis*, sp. n.	..	..	1	..	..	1	2
7. *Rhabditis monohystera* Bütschli	1	1	..	..	..	..	2
8. *Rhabdolaimus terrestris* de Man	..	5	..	..	..	19	24
9. *Enoplochilus obtusicaudatus*, gen. et sp. n.	1	..	..	..	..	2	3
10. *Achromadora tenax* (de Man)	..	..	1	..	..	..	1
11. *Dorylaimus stagnalis* Dujardin	..	..	..	..	..	3	3
12. —— *filiformis* Bast. f. *typicus* Micoletzky	1	..	..	2	..	..	3
13. —— *filiformis* Bast. f. *typicus* Mic. sf. *attenuatus* (de Man)	..	1	1	..	..	..	2
14. —— *filiformis* Bast. f. *longicaudatus* (v. Daday)	..	5	1	10	..	21	37
15. —— *unipapillatus* (v. Daday)	..	..	..	2	1	2	5
16. —— *paraguayensis*, sp. n.	1	24	..	30	..	38	93
17. —— *annulatus* v. Daday	..	1	..	..	..	2	3
18. —— *homalopapillatus*, sp. n.	3	1	1	3	..	..	8
19. *Actinolaimus tripapillatus* (v. Daday)	3	10	..	36	12	41	102
Total	40	53	12	100	13	147	365

♀$_e$, female with eggs.
♀, mature female without eggs.
(♀), juvenile female.
♂, mature male.
(♂), juvenile male.
j, juvenile.

The table shows that *Actinolaimus tripapillatus* is the most frequent species. *Dorylaimus paraguayensis* and *Trilobus diversipapillatus* are also present in large numbers. Less frequent, but still relatively common, are *Dorylaimus*

filiformis f. *longicaudata* and *Rhabdolaimus terrestris.* The distribution, expressed in percentages of the total number, is as follows :—

		Per cent.
1.	*Actinolaimus tripapillatus*	31·5
2.	*Dorylaimus paraguayensis*	25·6
3.	*Trilobus diversipapillatus*	15·9
4.	*Dorylaimus filiformis* f. *longicaudata*	10·1
5.	*Rhabdolaimus terrestris*	6·5
6.	*Trilobus parvipapillatus*	3·5
	Total	93·1

The remaining 6·9 per cent. is divided among the other thirteen species.

The table also shows the distribution of the sexes. We see that the total number of females (105) is nearly the same as that of males (113). It may be noticed that in certain species (e.g. *Actinolaimus tripapillatus*) the males predominate, and in others (e.g. *Trilobus diversipapillatus*) the females, but we cannot disregard the fact that the capture of nematodes in relation to the sexes is entirely governed by chance. Accordingly, the numbers have no general value.

The biological peculiarities and the anatomical characteristics of the different species are mentioned in the descriptions of each.

List of the habitats.*

Localities.—Makthlawaiya, 23° 25′ S., 58° 19′ W.; Nanahua, 23° 30′ S., 59° 30′ W.

Descriptions of the most frequently investigated habitats :—

(A_1) Swamp in the neighbourhood of Makthlawaiya. A position in the outer part of the swamp, dry only during prolonged drought. Water 0–3 ft. deep, covered with floating vegetation (*Pistia*, *Salvinia*, *Azolla*, etc.). Bottom, black mud.

(A_2) A similar position near the edge of the swamp at Makthlawaiya, but with less floating vegetation at the surface of the water.

(B) A position near the middle of the swamp at Makthlawaiya. Clear water without aquatic vegetation, but lying at the roots of dense clumps of tall rushes (*Typha* and other plants). Depth about 3 ft.

(C) Small rain-water pool in the grassland near Makthlawaiya, occupying a natural hollow in the ground and filled with water only after rain. Bottom, peat. Depth 2 ft.

* A general account of the country and fuller descriptions of most of these habitats are given in the first paper of this series (Carter, G. S., and Beadle, L. C., J. Linn. Soc. London, Zool. xxxvii, p. 205, 1930).

(D) Another rain-water pool in grassland at Makthlawaiya, but occupying a hole from which soil had been dug. Bottom, grey mud above clay. Depth 3–4 ft.

(E) Water on flooded land at Makthlawaiya, mostly shallow (about 1 ft. deep), but with a deeper part where a hole had been dug (5 ft.). Bottom, peat in the shallower part, grey mud in the deeper.

List of samples.

Makthlawaiya.

No.	Date.	Habitat.
179.	9. 10. 26.	D., surface.
182.	9. 10. 26.	E., surface; deeper part.
236.	16. 10. 26.	Saline pool in the bed of the Rio Verde, 5 miles NW. of Makthlawaiya. Density 1014·8. Surface.*
357.	4. 12. 26.	A_2, after rain.
386.	25. 11. 26.	Pools near the edge of the swamp at A_2.
388.	29. 11. 26.	Pool near the edge of the swamp at A_2.
390.	29. 11. 26.	D, bottom water.
717.	27. 12. 26.	A_2, amongst floating weed.
718.	29. 12. 26.	Shallow rain-water pool in a pasture 5 miles S. of Makthlawaiya.
719.	6. 1. 27.	A_1, among floating vegetation.
1146.	12. 4. 27.	Rio Siete puntas, a muddy stream passing through grassland 40 miles SE. of Makthlawaiya.
1153.	19. 4. 27.	Rain-water pool near the shore of the Rio Verde at the same place as no. 236. Not saline.
1222.	27. 4. 27.	Pool in a wood near Makthlawaiya. Bottom, grey sandy mud.
1224.	26. 4. 27.	C.
1264.	4. 5. 27.	C.
1265.	5. 5. 27.	B.
1266.	5. 5. 27.	Rain-water pool in pasture near Makthlawaiya.
1267.	6. 5. 27.	A_2.
1270.	11. 5. 27.	A_1, position in the centre of the swamp at Makthlawaiya, similar to B.
1272.	11. 5. 27.	A_1, among the floating vegetation.
1281.	18. 5. 27.	Rio Verde, 15 miles NW. of Makthlawaiya. Rain-water pool near the river. Not saline.
1311.	27. 5. 27.	C.
1313.	27. 5. 27.	Water on flooded ground to the E. of E. Shallow.

* An analysis of this water has been given in the paper by Carter and Beadle previously mentioned (p. 256).

Nanahua.

No.	Date.	Habitat.
985.	5. 2. 27.	Pool in a pasture NE. of Nanahua.
1117.	16. 3. 27.	Pool in a pasture 2 miles NE. of Nanahua.
1118.	16. 3. 27.	An old well near 1117.
1120.	15. 3. 27.	Pool in a wood 5 miles NE. of Nanahua.
1126.	17. 3. 27.	An old well, 3 miles N. of Nanahua.
1129.	19. 3. 27.	Pool in the riacho of the Rio Monte Lindo, near Nanahua, not saline.

APHANOLAIMUS DUODECIM-PAPILLATUS, sp. n. (Text-fig. 1.)

Total number, 1 male.

Size : L, 0·923 ; a, 31·8 ; b, 4·5 ; c, 7·8 ; G, 53·3 per cent.

*Proportional widths of the body.** —14 : 61 (middle of the oesophagus) : 89 : 100 : 78 : 14.

Body.—Slender, very much reduced anteriorly, being a little more than one-seventh of the maximum width of the body. Commencing with the anus the posterior end becomes noticeably smaller.

Cuticle.—Distinctly striated : the annulation begins in front just behind the amphids and goes nearly to the posterior extremity of the body. No bristles except the head-bristles. The lateral cords have glands, but their number could not be determined, because the specimen was not very well preserved. They are more marked in the region of the praeanal papillæ.

Head.—Similar to that of *Aph. aquaticus* (v. Daday), and a figure is unnecessary. At the anterior end four long, fine bristles arise from the head. These are 4·7 μ long, a length equal to six-fifths of body-width at the point of attachment. Mouth-cavity absent. Amphids large, oval, nearly circular, the width being 3·3 μ, which is about four-fifths of that of the body.

Oesophagus.—Typical, a slight swelling at the posterior end, but not forming a distinct bulb. Width at the anterior end 50 per cent., in the middle 33·3 per cent., and at the posterior end 56·2 per cent.

Rectum, half the anal width.

Tail (text-fig. 1 A, B).—Decreasing gradually towards the posterior end. Ending in an end-tube, which is not well differentiated. This end-tube has a terminal tubulus, cut off straight, the walls of which have a cuticular reinforcement. Tail-glands are very probably present, but were not seen.

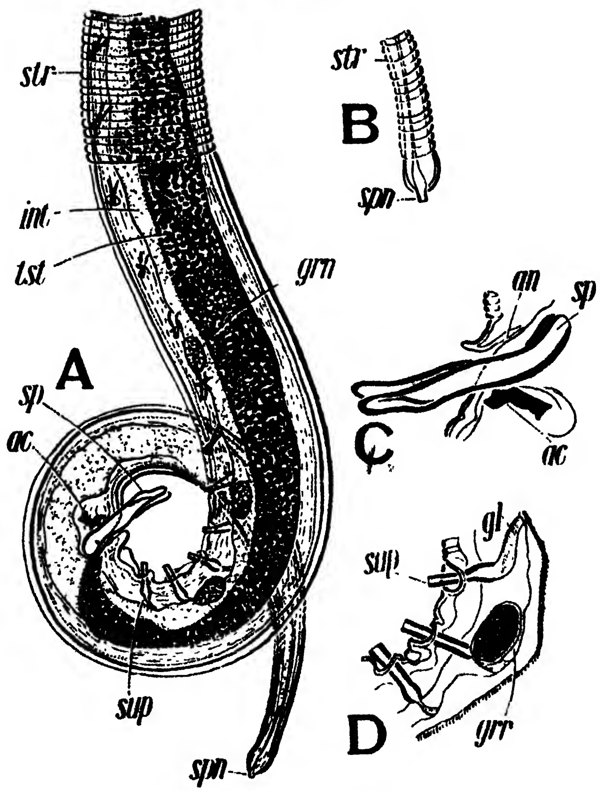
Male sexual organ (text-fig. 1 A, C, D).—Testis long and straight, not paired, taking up 40·7 per cent. of the whole length of the body. It begins a little more than twice the length of the oesophagus down the body. Spicula large, nearly straight, reminding one strongly of that of *Aph. aquaticus* (cf. the figure of v. Daday (6), *Aph. anisitsi*, tab. i, fig. 6). Proximal end rounded,

* Taken in succession at the anterior end, nerve-ring, posterior end of the oesophagus, vulva, maximum width, anus, posterior end.

and then suddenly narrowed before the distal end, which is finger-shaped. Length 34 μ or $1\frac{1}{2}$ anal width. Gubernaculum simple, a flattened rod, having an irregular outline: size 8·5 μ or $\frac{1}{4}$ spicula-length. There are 12 praeanal papillae. All are rod-shaped and have thin walls. They are hollow. A secretory duct goes to each papilla. Size of the papilla 8–9 μ. The arrangement of the papillae as compared with the anal width, from anterior to posterior, is :—

1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.
7·6	6·6	5·9	5·1	4·5	3·8	3·1	2·5	2·1	1·5	1·1	0·7

TEXT-FIG. 1.



Aphanolaimus duodecim-papillatus, sp. n.

A. Posterior end of the male. Oil-im. 1/12, oc. 4. ×900.
B. Tail-club of the male. Oil-im. 1/12, K 18. ×1800.
C. Spicular apparatus. Oil-im. 1/12, K 18. ×1800.
D. Praeanal papillae. Oil-im. 1/12, K 18. ×1800.

Affinities.—The species is very similar to *Aph. aquaticus* (v. Daday, 6), as previously mentioned. It is also related to *Aph. multipapillatus* v. Daday (7). It is probably an intermediate form between these two species. Indeed,

Micoletsky (13, 15) has already found that the number of the papillae is variable. He found 8–11 papillae in *Aph. aquaticus*. Our species is differentiated from these two by its differently formed spicula-apparatus.

Habitat.—Ca 718*.

MONHYSTERA PALUDICOLA de Man.

de Man, 1880, 1884; v. Daday, 1905; Micoletzky, 1914, 1917.

Total number, 4, of which ♀ 1_0; ♂ 2; j 1; sex-number 200.

	♀	♂
Size:	L, 0·959.	L, 0·751–0·814 (0·782)
	a, 33·5.	a, 32·1–34·8 (33·4)
	b, 7·2.	b, 4·75–6·5 (5·6)
	c, 4·7.	c, 6·5–7·4 (6·9)
	V, 56·4 per cent.	G, 59·3 per cent.
	G, 38·5 per cent.	nr, 59·7 per cent.
	En, 1.	
	Es, 16 : 39 μ.	
	nr, 49 per cent.	

(♂ values L to c: 2.)

Juv. L, 0·728; a, 40; b, 6·2; c, 4·7.

Proportional widths of the body.—

♀. 32 : 63 : 73 : 100 : 91(V) : 54 : 9 (width of the posterior end).

♂. 38 : 71 : 83 : 100 : 66 : 11. n, 2.

I have nothing to add to the descriptions of de Man (12) and Micoletzky (13). The specimens are exactly like those described by these authors. This species was also identified by v. Daday (7) in his material from Paraguay. Comparisons of the size-relations of the different parts of the nematode may be given.

Amphids. ♀, ¼; ♂ 1/3·5 of the corresponding width.

Oesophagus-width.

	Anterior end.	Nerve-ring.	Posterior end.
♀	50 per cent.	42 per cent.	62·5 per cent.
♂	66·6 per cent.	50–57 (53·8) per cent.	57–62·5(59·7)per cent.

Spicula-length. 49–52 μ (50·5 μ) or not quite half tail's length.

Habitat.—Ca 386, 719, 1270, 1282.

MONHYSTERA ANNULIFERA v. Daday. (Text-fig. 2.)

v. Daday, 1905.

Total number, 1 female.

Size.—L, 0·728; a, 21·5; b, 9·0; c, 6·5; V, 52·2 per cent.

Proportional widths of the body.—39 : 61 : 69 : 100 : 92(V) : 54 : 15.

This species was first found by v. Daday (7) in Paraguay. My specimen is so similar to his form that I believe that I have found again the species

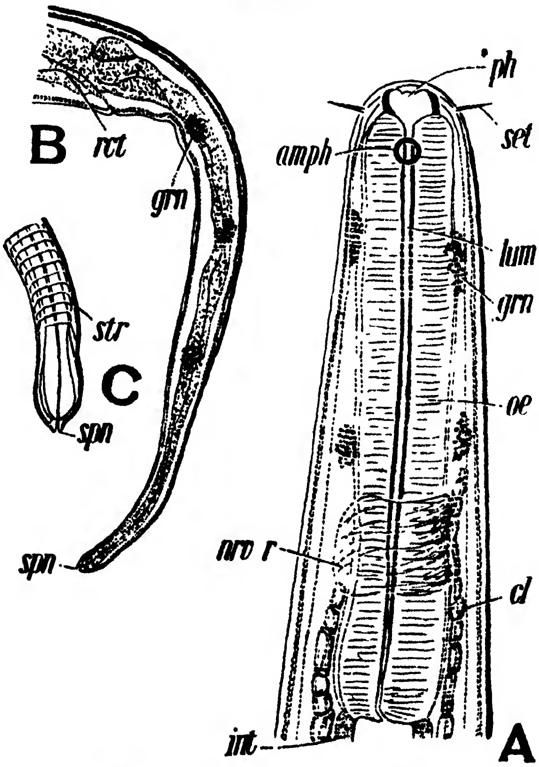
* This and similar references refer to the numbers of the samples in the list given on p. 58.

described by him. The following points must be added to the specific description :—

Body.—Rather robust ; the anterior part not quite one-third of the greatest width. Posterior end elongate.

Cuticle.—In two layers. The fine exterior layer is very smooth, whereas the inner layer shows a marked annulation, but this annulation is so fine that it can only be seen with the highest powers. Thickness, 0·8 μ. Numerous

TEXT-FIG. 2.



Monhystera annulifera v. Daday.

A. Anterior end of the female. Oil-im. 1/12, K 18. ×1800.
B. Posterior end of the female. Oil-im. 1/12, oc. 4. ×900.
C. Tail-club of the female. Oil-im. 1/12, K 18. ×1800.

dark brownish-yellow accumulations of pigment, present in groups throughout the body, are very conspicuous. They are arranged somewhat regularly in front of the nerve-ring, the pigment-granules occurring in two groups. Three such accumulations were seen in the postanal part.

Head (text-fig. 2 A).—Rounded, without lips or papillae. There are four long fine bristles, which have a length equal to half the corresponding body-width. Mouth-cavity large, bowl-shaped, with a conspicuous cuticular ring, conforming approximately to the statements of v. Daday. The walls of the ring are

rather thick and resemble a half-crescent. No further inner structure in the cavity could be seen. Size 4·8 μ, or two-thirds of the corresponding width. Amphids circular, one-fifth of the corresponding width, very difficult to find ; they are smaller than those in v. Daday's specimens, which were larger than one-fourth of the corresponding width.

Oesophagus (text-fig. 2 A).—Nearly cylindrical, very short, being shorter than in v. Daday's specimens (b, 6·5 against b, 9). The oesophagus begins directly behind the pharynx. The relatively large lumen has a very fine cuticular intima. Width of the oesophagus at the anterior end, 66·6 per cent. ; at the nerve-ring, 62·5 per cent ; and at the posterior end, 55·5 per cent. The nerve-ring is two-thirds of the way down the oesophagus, i.e. 67·8 per cent. of the whole length. At the posterior end of the oesophagus there are irregular, clear cells, which are refractive. Those behind the nerve-ring can be best seen. Their function is unknown.

Ventral gland not seen.

Intestine.—Regular in form. Rectum=width of anus.

Tail (text-fig. 2 B, C).—Gradually decreasing and then slightly swelling, slightly club-shaped at the end. The subcuticular annulation is visible only as far as the club. Caudal glands ?.

Female sexual organs.—Ovary unpaired, extending anteriorly. Length of the gonad 20 per cent. of the whole length of the body. Vulva simple, placed a little behind the middle of the body, i.e. 52 per cent. behind the anterior end. As the nematode was not mature, all the female reproductory organs would have grown larger in the course of its further development.

Proportions of the posterior end.—Length of the tail 7·5 ; width of the club 0·25.

Habitat.—Ca 718.

TRILOBUS DIVERSIPAPILLATUS v. Daday. (Text-fig. 3.)

v. Daday, 1905 ; Cobb, 1914, *Trilobus longus*, sp. n. (5).

Total number, 58, of which ♀ 35, of which 28_0 and (6) ; ♂ 13 ; juv. 10 ; sex-number, 37.

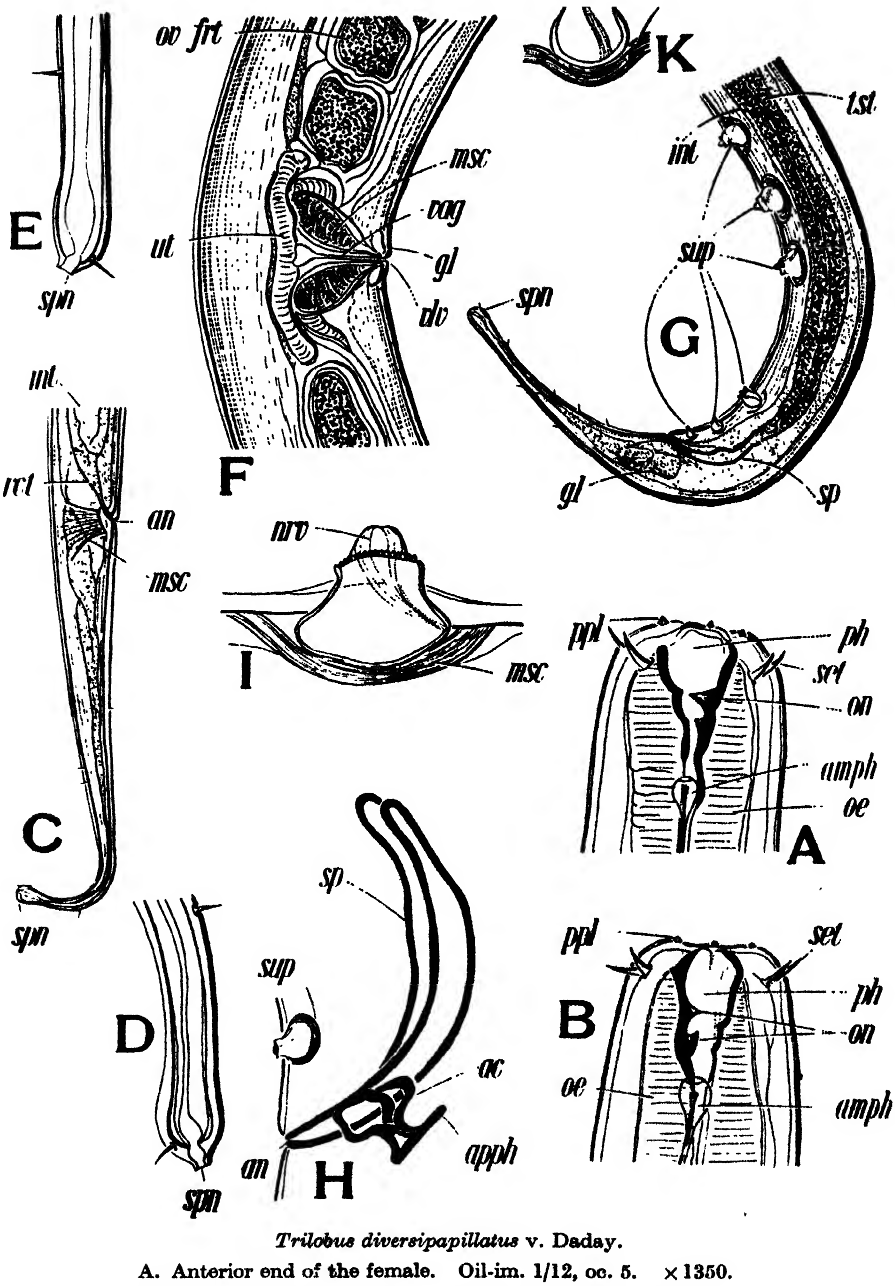
Size :

♀. L, 1·695–2·241 (2·059)
a, 23·9–35·3 (29·8)
b, 5·7–6·4 (6·2)
c, 8·8–10·0 (9·3)
nr, 33·6–39·8 (37·0) per cent.
V, 34·6–41·5 (38·9) per cent. } 10.
G_1, 14·1–18·4 (16·9) per cent.
G_2, 17·0–23·0 (19·8) per cent.
En, 4–10 (6)
Es, 21–29 : 31–42 μ (31 : 37 μ)

♂. L, 1·141–1·685 (1·436)
a, 32·9–39·8 (36·0)
b, 5·2–6·0 (5·5)
c, 11·1–14·8 (12·7) } 10.
nr, 35·6–43·2 (38·2) per cent.
G, 58·9–66·0 (62·1) per cent.

Proportional widths of the body.—

♀. 40 : 58 : 76 : 96(V) : 100 : 45 : 7 (tail-club) } 10.
♂. 47 : 77 : 84 : 100 : 70 : 13



Trilobus diversipapillatus v. Daday.

A. Anterior end of the female. Oil-im. 1/12, oc. 5. ×1350.
B. Anterior end of the male. Oil-im. 1/12 K 18. ×1800.
C. Posterior end of the female. Obj. 4, oc. 4. ×400.
D. Tail-club of the female. Oil-im. 1/12, K 18. ×1800.
E. Tail-club of the male. Oil-im. 1/12, K 18. ×1800.
F. Structure of the vulva. Obj. D, oc. 5. ×600.
G. Posterior end of the male. Obj. D, oc. 4. ×400.
H. Spicular apparatus. Oil-im. 1/12. K 18. ×1800.
I. 2nd praeanal papilla. Oil-im. 1/12, K 18. ×1800.
K. 4th praeanal papilla. Oil-im. 1/12, K 18. ×1800

This species was first established by v. Daday in 1905, who found it in his material from Paraguay, but his description needs to be supplemented and corrected in so many ways that it will be better to describe the species again :—

Body.—Not very slender, the male being thinner than the female. In both sexes the width of the anterior end is less than half of the maximum width of the body. The posterior end tapers gradually to a club-shaped tail.

Cuticle.—Smooth, not striated, relatively thin : female 2–3·9 μ (2·7 μ), male 2·6–5·2 μ (3·2 μ). Under a high power there can be seen a very fine annulation in the exterior cuticle, while in the sub-cuticle there are crystalloids arranged longitudinally. They show clearly in the oesophageal region, and give a granular appearance to the tissue. Micoletzky (16) has already called attention to the existence of these crystalloids in his studies on the nematodes of Denmark, where they seem to be typical of *Tr. gracilis*, a fact which indicates the near relation of the present species to this one. But I believe that it does not justify us in uniting the two species, as Micoletzky proposed. Irregularly arranged bristles cover the whole body. Lateral fields are narrow, with no special peculiarities.

Anterior part (text-fig. 3 A, B).—Rounded with six distinctly formed lips. Each lip bears a papilla which resembles a bristle. Head-bristles 10, regularly arranged. Length : female 4·8 μ, male 3·2 μ.

Oral cavity.—Widely open. Vestibule large, with thin walls. Pharynx proper, large, divided into two parts, a cup-shaped anterior part and a narrower conical basal portion. The anterior broader, but shorter, part has its walls bent outwards and strongly cuticularised. A prominent dorsal tooth, which is at the beginning of the conical posterior part, projects a considerable distance into the interior of the cavity. On the ventral side there is only a little tooth-like point. The posterior part has on the ventral side a tooth-shaped projection and on the dorsal a small tooth just behind the large tooth. Size : female 9·6–21·1 μ, male 5·9–14·7 μ.

Amphids.—A little smaller in the female than in the male ; to be found almost as far down the oral cavity as the lumen of the oesophagus. They are oval and contain within them a conspicuous club-shaped nerve-cell, the branches of which disappear in the tissues of the oesophagus. Size : female one-eighth, male one-sixth, of the width of the body at this point.

Oesophagus.—Regular. It is broad at the anterior end and has at the posterior end the glandular organs which are typical for the genus. Nerve-ring relatively narrow, just behind the anterior third of the oesophagus : female 33·6–39·8 per cent. (37 per cent. ; n, 10) ; male 35·6–43·2 per cent. (38·2 per cent. ; n, 10). Width at the anterior end : female 60–80 (69·4) per cent., male 55–66·6 (60·3) per cent. ; at the nerve-ring : 41·1–62·5 (49) per cent. resp. 35·7–55·5 (45·6) per cent. ; and at the posterior end : 44–60 (51·3) per cent. resp. 46·6–58·3 (51·6) per cent.

Intestine.—Regular. The length of the rectum is the same as, or a little more than, the anal width.

Tail (text-fig. 3 C–E, G).—In the female gradually reduced and ending in a slight end-club; in the male at first conical, then nearly cylindrical, and at the end swelling to a distinct club. The conical part is nearly half the total length of the tail. The bristles of the tail in the male are stronger than those of the female. The tail-club has a distinct excretory tube, which connects with the caudal glands. The glands themselves could not be seen with certainty.

Female sexual organs (text-fig. 3 F).—Ovary paired, symmetrical; anterior ovary generally a little shorter than the posterior. The structure of the ovary is very regular, its single cells are placed one on top of the next like a pile of coins. Vulva, which is a little more than a third of the way down the body, is normally formed; vagina very narrow; uterus lying in the axis of the body, with a single cavity. The whole vagina is covered with a layer of muscle, which is striated radially and is reticulate. The uterus itself lies in a well-developed muscular tube. The development of the musculature is closely related to the development of the eggs, which are very numerous, as many as five being in each oviduct. Being extremely thick-shelled, they need a strongly formed vaginal musculature for their expulsion. The whole apparatus, including the modified character of the eggs, is an adaptation to the biological conditions in which the animal is forced to live. The nematode needs protection against desiccation, as in the case of *Actinolaimus tripapillatus* (v. Daday) (Kreis, 10). The thick-shelled eggs and the well-developed musculature have been evolved for this purpose. Two little glands are to be seen on each side of the vagina.

Male sexual organs (text-fig. 3 G–K).—Here the inaccuracy of the observations of v. Daday is again obvious. The testis is long, extending a great distance forward. Spicula arcuate, proximally capitate and rounded, distally not pointed. The two spicula-margins do not unite at the posterior end, but lie very close to each other. Size 39–52 μ (47·1 μ). The accessory plate is very complicated: it consists of a plate upon which lies an anvil-shaped appendage, having at its end a rod-like appendage, which is very long anteriorly, but posteriorly very short. Probably the plate surrounds the spicula. The observations made by v. Daday do not correspond with these facts. There are two groups of three praeanal papillae; the anterior group is composed of large papillae of normal form (text-fig. 3 I), each with a large oval gland-mass buried in the tissues. On this gland there is an extended calotte, which is distinctly fringed and on which stands the true excretory tube, spherical in shape. A nerve, which enters the papilla, divides anteriorly and then extends over the entire surface of the tube. The posterior group of papillae is much simpler (text-fig. 3 K): the papillae are small, particularly the papilla which is directly in front of the anus. A secretory reservoir is present, and a calotte, but both are simpler than in the anterior papillae. The calotte is not fringed; it has only small, delicate, papilla-shaped prominences. The tubulus is connected with the nerves.

Size of the large papillae 15·6–18·2 : 16·9 μ ; 4th papilla 7·8 : 10·4 μ ; 5th papilla 6·9 : 7·8 μ ; 6th papilla 5·5 : 5·2 μ.

Distance of the papillae from the anus (measured in anal widths) :—4·8–7·4 (6) ; 3·8–5·9 (4·7) ; 2·9–4·4 (3·6) ; 1·2–1·8 (1·4) ; 0·7–1·3 (0·8) ; 0·2–0·9 (0·3). n, 10.

Habitat.—Ca 236, 357, 388, 717, 718, 719, 1224, 1264, 1266, 1267, 1273.

TRILOBUS PARVIPAPILLATUS, sp. n. (Text-fig. 4.)

Total number, 13, of which ♀ 5, of which 1_0 and (1) ; ♂ 1 ; juv. 7 ; sex-number 20.

Size :

♀. L, 1·281–1·903 (1·548)		♂. L, 1·266	Juv. L, 0·562–1·274
a, 30·5–37·2 (34·3)		a, 32·5	a, 29·0–44·6
b, 5·2–6·2 (5·6)		b, 5·2	b, 3·8–5·35
c, 7·1–12·9 (9·5)	} 7.	c, 9·9	c, 6·2–8·6
nr, 37·9–41·5 (39·1) per cent.		nr, 37·2 per cent.	
V, 41–44·7 (42·7) per cent.		G, 57·3 per cent.	
G_1, 11·4–18·2 (13·9) per cent.			
G_2, 12·4–17·7 (15·2) per cent.			
En, 4	} 1.		
Es, 31 : 44 μ			

Proportional widths of the body.—

♀. 44 : 74 : 89 : 98 : 100 : 59 : 12. n,4.

♂. 40 : 80 : 87 : 100 : 67 : 13.

Body.—Elongated, slender ; the anterior end is two and a half times the largest diameter ; the posterior end tapers gradually.

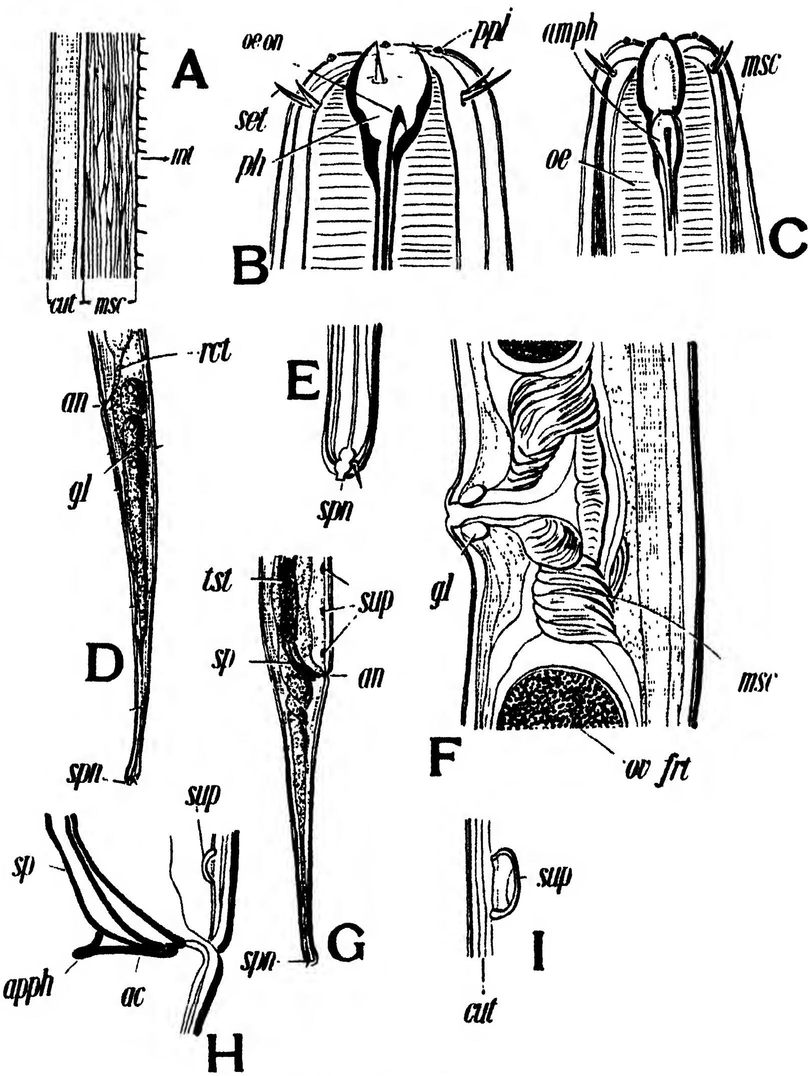
Cuticle (text-fig. 4 A).—Relatively thick, 2·6 μ ; of several layers (cut.). Under the thin exterior layer is a thicker layer which is probably striated longitudinally. Very narrow 3rd and 4th layers can also be seen. There are irregularly arranged bristles over the whole body.

Musculature (text-fig. 4 A).—The subcuticular musculature is very well developed. It is very distinct over the whole body from the anterior end to the tail ; it is composed of longitudinal fibres which begin in the region of the posterior oral cavity and continue almost to the tail-club. It appears from the arrangement of the muscles that the nematode is very agile.

Anterior end (text-fig. 4 B & C).—Rounded with the normal lips, each of which bears a distinct papilla. Ten head-bristles, regularly arranged, each one-fourth of the corresponding width of the body.

Mouth-cavity.—There is some dimorphism of the pharynx between the two sexes. The cavity in the male is narrower than in the female. The largest width in the female (text-fig. 4 B) is nearly half of the corresponding width of the body, while the cavity in the male is only one-third of this width. The pharynx is divided into two parts. The anterior part is broadly oval in the female, and longish oval in the male. There is dorsally and ventrally a very

TEXT-FIG. 4.



Trilobus parvipapillatus, sp. n.

A. Development of the cuticle in the female. Oil-im. 1/12, K 18. ×1800.
B. Anterior end of the female. Oil-im. 1/12, K 18. ×1800.
C. Anterior end of the male. Oil-im. 1/12, K 18. ×1800.
D. Posterior end of the female. Obj. D, oc. 4. ×400.
E. Tail-club of the female. Oil-im. 1/12, K 18. ×1800.
F. Structure of the vulva. Oil-im. 1/12, oc. 4. ×900.
G. Posterior end of the male. Oil-im. 1/12, oc. 2. ×720.
H. Spicular apparatus. Oil-im. 1/12, K 18. ×1800.
I. Praeanal papilla. Oil-im. 1/12, K 18. ×1800.

small tooth-shaped point. In the female there is no distinct division between the end of the cavity and the beginning of the lumen of the oesophagus, but in the male the posterior half of the pharynx has a second indentation, which tapers gradually into the lumen of the oesophagus. Size of the mouth-cavity: female 6·5–10·4 : 13–16·9 (7·8–15·3 μ), male 5·2 : 15·6 μ. In addition, there is also a prominent subdorsal tooth on the oesophagus. The *amphids*, which are small and very difficult to see, could only be observed in the male. Their form is longish oval, their size about one-fifth of the corresponding width of the body. They are just behind the anterior part of the mouth-cavity.

Oesophagus.—Regular, normal. Width of the anterior end: female 62·5–77·7 (70·8) per cent., male 71·5 per cent.; at the nerve-ring: 42·8–54·5 (48·3) per cent. resp. 41·6 per cent. and of the posterior end: 46·7–53·3 (50) per cent. resp. 46·1 per cent. Nerve-ring narrow, just behind the first third of the oesophagus: female 37·9–41·5 (39·1) per cent., male 37·2 per cent.

Intestine.—Regular. Rectum a little longer than the width of the anus.

Tail (text-fig. 4 D, E, G).—More slender and longer in the female (text-fig. 4 D) than in the male (text-fig. 4 G). A slight end-club having a distinct secretory tube and a terminal bristle (text-fig. 4 E). Internally there are three tail-glands, which lie in a line, the most anterior being beside the anus. The secretory canal has two indentations at its posterior end.

Female sexual organs.—Ovary paired, symmetrical: ovarian cells arranged one on top of the next like a pile of coins. Vulva (text-fig. 4 F), situated a little in front of the middle of the body, is normally developed and is slightly elevated. The vagina remains narrow and extends a little more than half the width of the body into the interior. The uterus has a single cavity. Oviduct with a distinct circular musculature, which causes the movements of the eggs. The eggs, which are relatively large (31 : 44 μ), have extremely thick shells (as in *Trilobus diversipapillatus* v. Daday).

Male sexual organs.—Testis a little more than half the length of the body. Spicula (text-fig. 4 G, H) slightly curved. Proximal end capitate; distal end pointed. Length 25 μ, i.e. nearly anal width. Gubernaculum small, skirting the distal end of the spicula, and having a conspicuous posterior process, set transversely to the body's axis. Six praeanal papillæ in two groups. The papillae (text-fig. 4 I) are markedly small. Under the highest power no internal structure can be seen. The papilla directly in front of the anus is so small that it can very easily be overlooked. The distances of the papillae from each other in anal widths are (from anterior to posterior): 6·3, 5·1, 3·9, 1·8, 1·0, 0·4.

Proportions at the posterior end.—Length of the tail: female 7, male 5; width at the end: 0·25 resp. 0·2; spicula 1·0: gubernaculum 0·5.

Affinities.—The species is closely related to *Tril. gracilis* Bastian, but it differs from this form in the development of the spicular apparatus, and above all in the very small papillae arranged in two groups. Also, there are no crystalloids which are typical of *Tril. gracilis*.

PLECTUS PARAGUAYENSIS, sp. n. (Text-fig. 5.)

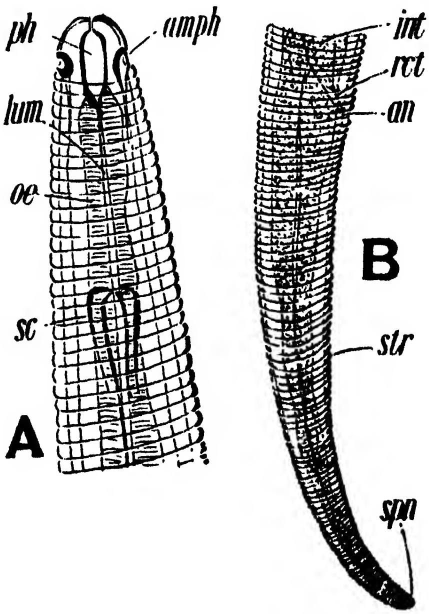
Total number, 2, of which ♀ (1) and juv. 1.

Size.—♀. L, 1·113 ; a, 53·6 ; b, 5·1 ; c, 9·1 ; V, 53 per cent. ; nr, 50 per cent.

Proportional widths of the body.—♀. L, 31 : 37 : 50 : 75(V) : 100 : 62 : 18 (end of the tail).

Body.—Very slender, the anterior end of the body being not quite as wide as the posterior end of the oesophagus. Posterior end of the body tapers gradually.

TEXT-FIG. 5.



Plectus paraguayensis, sp. n.

A. Anterior end of the female. Oil-im. 1/12, K 18. ×1800.
B. Posterior end of the female. Oil-im. 1/12, oc. 4. ×900.

Cuticle.—Coarsely striated. The striation begins just behind the amphids and extends to the end of the tail. Thickness 1·9 μ.

Anterior end (text-fig. 5 A).—Rounded. Without lips, papillae or bristles. Oral cavity relatively large, one-thirteenth of the total length of the oesophagus ; of an elongate hexagonal shape, one-third as wide as the body at the same level. Walls strongly cuticularised. The amphids are near the anterior end and normal in form : they have a distinct duct, which disappears in the tissues of the oesophagus. In lateral view the amphids appear buried in the substance of the body. Their exterior border is strongly cuticularised.

Oesophagus.—Elongate, narrow, agreeing in structure with that of *Pl. tenuis* Bastian (de Man, 12). The cuticular framework which serves to reinforce the oesophagus lies two and a half pharynx-lengths behind the oral cavity. It is one and a half times as long as the oral cavity and is very strongly developed. Probably the scaffold consists of eight cuticular rods, which are arranged radially and extend posteriorly. Towards the anterior end they bend towards each other (text-fig. 5 A). The end-bulb, 11 : 16 μ, has a distinct valvular apparatus. Nerve-ring at the middle of the oesophagus. Width at the anterior end 50 per cent.; at the nerve-ring 50 per cent., and at the posterior end 57·2 per cent.

Tail (text-fig. 5 B).—Elongate, conical, with rounded posterior end, striated along its whole length. Glands not seen.

Female sexual organs.—Vulva a little behind the middle of the body. Nothing can be said about the arrangement of the ovary, since the single available female had undeveloped genital organs.

Affinities.—The species is closely related to *Pl. tenuis* Bastian. The differences between the two species are as follow :—

(1) The form of the oral cavity;

(2) The development of the scaffold of the oesophagus ; and

(3) The more slender body and the longer tail in our species.

Habitat.—Ca 717, 1270.

RHABDITIS MONHYSTERA Bütschli.

Syn. *Rh. simplex* Cobb.

Butschli, 1873; Cobb, 1893, 1906; Hofmänner und Menzel, 1915; Micoletzky, 1917, 1922.

As the species is one of the commonest of the genus *Rhabditis*, only the measurements will be given :—

Total number, 2 ♀, of which 1_0.

Size :	L, 0·478–0·616 (0·548)	V, 69·6–74·6 (72·6) per cent.
	a, 20·4–23·7 (21·0)	En, 1
	b, 4·4–4·5 (4·45)	Es, 15·5 : 31·2 μ
	c, 8·6–11·3 (9·0)	

Proportional widths of the body.—31 : 47 (beginning of the oesophagus) : 74 : 85 : 100 : 84 : 47.

Length of the oral cavity.—13 μ or one-eighth to one-tenth of the whole length of the oesophagus.

Cuticle.—Finely striated, 0·8–1·9 μ thick.

Oesophagus widths.—Anterior end 50 per cent; middle 57·1 per cent.; posterior end 62·5 per cent.

Size of the bulb.—13 : 15·6–20·8 μ.

Habitat.—Ca 388, 717.

Rhabdolaimus terrestris de Man.

de Man, 1884.
Cobb, 1914, *Rhabdolaimus minor* Cobb.

Total number, 24, of which ♀ 5 and juv. 19.

Size : ♀. L, 0·333–0·471 (0·392)	3.	nr, 58·8–60 (59·4) per cent.	2.
a, 21·3–28·8 (26·2)		V, 39·8–46·8 (43·7) per cent.	3.
b, 4·9–6·0 (5·5)		G_1, 10·1 per cent.	1.
c, 3·1–3·5 (3·3)	2.	G_2, 17·2 per cent.	

Juv.—L, 0·312–0·342 ; a, 26·2–27·3 ; b, 4·5–5·7 : c, 3·6–3·9.

Proportional widths of the body.—♀. 31 : 81 : 86 : 94(V) : 100 : 64 : 17. n, 3.

The specifications as to size given by de Man (12) and Micoletzky (15) agree with those of the present specimens. It should be added that the nerve-cells, which Cobb (5) has noticed, are well developed. Although all these specimens were found in non-permanent pools, it is clear that they must be included in the group '*terrestris*'.

Size-proportions in the oesophagus.—Width of the anterior end 75 per cent., at the nerve-ring 50–75 (61·7) per cent., and of the posterior end 60–80 (73·3) per cent. n, 3.

Position of the nerve-ring.—58·8–60 (59·4) per cent. n, 2.

Thickness of the cuticle.—0·6 μ.

Habitat.—Ca 1146, 1224, 1311.

Enoplochilus, gen. nov.

(ἔνοπλος, armed; χεῖλος, lip.)

Body plump, rounded at both ends. Cuticle smooth. Three mobile and reinforced lips. Mouth-cavity elongate, tubiform, having a large median tooth. Amphids large, reniform. Oesophagus without bulb. Tail rounded. Female sexual organs unpaired, extended forwardly. Male unknown.

The present genus appears to be very closely related to *Ironus* Bastian ; but it differs from that genus not only in the construction of the pharynx and the amphids, but also in having unpaired sexual organs.

Type, *Enoplochilus obtusicaudatus*.

Enoplochilus obtusicaudatus, gen. et sp. n. (Text-fig. 6.)

Total number, 3, of which ♀ 1_0, juv. 2.

Size.—♀. L, 0·829 ; a, 18·7 ; b, 3·8 ; c, 22·8 ; V, 60·8 per cent.

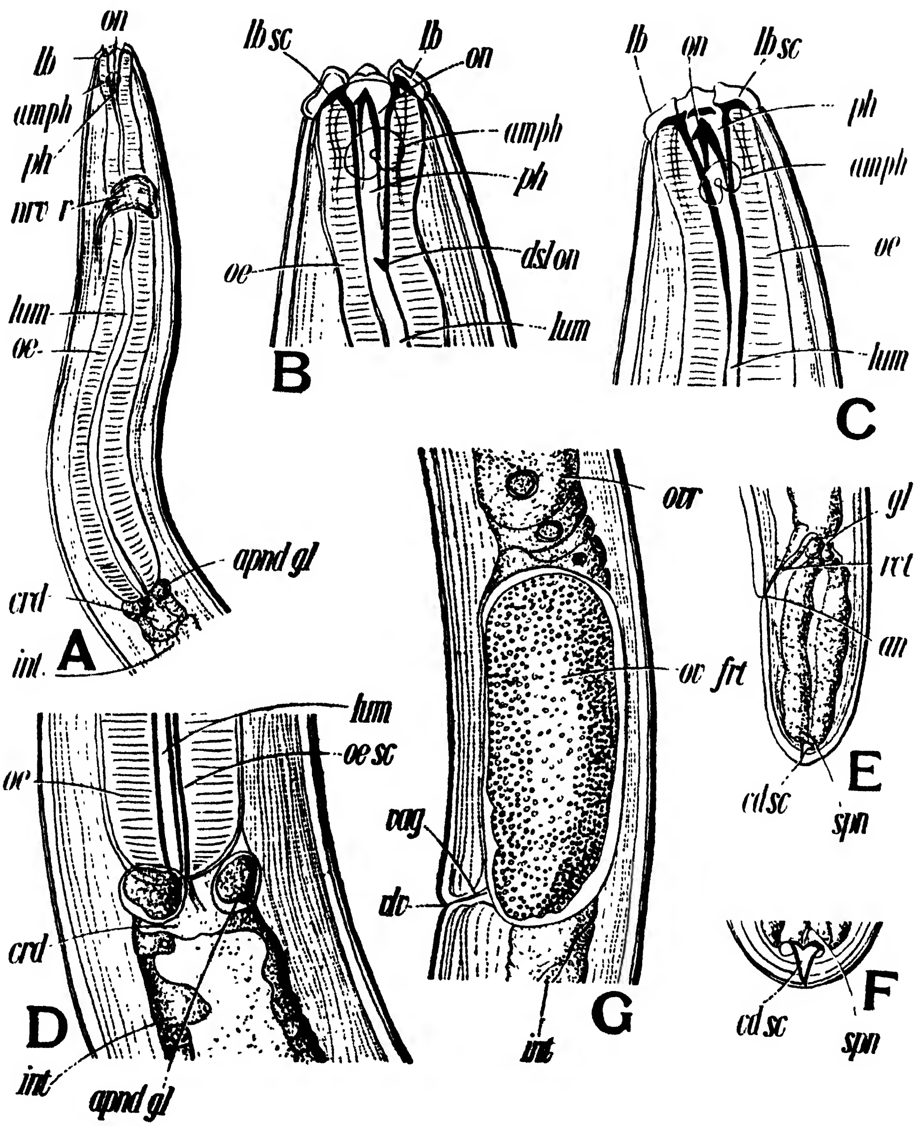
Juv. L, 0·407–0·780 ; a, 12·7–21·4 ; b, 3·0–3·6 ; c, 14·7–21·4.

Proportional widths of the body.—♀. 29 : 76 : 94 : 100 : 88(V) : 59.

Body.—Plump. The width of the anterior end not quite one-fourth of the maximum width. Posterior end not greatly reduced, rounded.

Cuticle.—Smooth, with two layers. The exterior layer is thin. Subcuticular musculature well developed.

TEXT-FIG. 6.



Enoplochilus obtusicaudatus, gen. et sp. n.

A. Anterior end of the female. Oil-im. 1/12, oc. 2. ×720.
B. Mouth of the female, open. Oil-im. 1/12, K 18. ×1800.
C. Mouth of the juv. specimen, closed. Oil-im. 1/12, K 18. ×1800.
D. Posterior end of the oesophagus in the female. Oil-im. 1/12, oc. 5. ×1350.
E. Posterior end of the female. Oil-im. 1/12, oc. 4. ×900.
F. Tip of the tail of the female. Oil-im. 1/12, K 18. ×1800.

Head.—The anterior end is sharply cut off. No bristles or papillae. There are three mobile lips which have a well-developed cuticular framework. At first sight the arrangement of the armament seems very similar to that of *Ironus* Bastian, but careful observations show that there are not teeth, but a true pillar-skeleton, reinforcing the lips. Each lip is connected with the oesophagus by means of a gland-duct. When the pharynx is closed, the cuticular reinforcements are transverse to the axis of the body (text-fig. 6 C). In this position their sharp points extend into the pharynx. When the lips are open (text-fig. 6 B), these reinforcements rise and their points extend anteriorly. Pharynx elongate, tubiform, 20 μ long, or one-tenth of the whole length of the oesophagus. The lumen of the oesophagus itself, which appears to be a continuation of the pharynx, does not possess any conspicuous cuticularisation. A large tooth lies in the middle line; its anterior end reaches almost to the front end of the reinforcements of the lips. Probably it is connected with the oesophagus, since it has a duct which runs backwards from its point. Just at the base of the pharynx there is a small dorsal tooth, but this seems to be absent in the young specimen. Amphids large, reniform, a little more than one-third of the corresponding width. The periphery of the amphid is not closed; on the posterior side the periphery passes inwards towards the centre, where a distinct circular pore may be seen deep down in the amphid. It may be concluded from this fact that the amphid is probably a secretory organ.

Oesophagus (text-fig. 6 A, D).—Very greatly elongate, nearly cylindrical, swelling a little at the posterior end. The very broad oesophagus starts just behind the lips. Its lumen is very wide, being one-fifth of the width of the oesophagus at the posterior end. Its intima appears to be cuticular, and this is particularly well developed at the posterior end (text-fig. 6 D). Width at the anterior end 80 per cent., at the nerve-ring 38·5 per cent., and at the posterior end 56·1 per cent. The nerve-ring is a short distance behind the anterior end, only 25 per cent. of the whole length of the oesophagus. Ventrally its nerve-tissue disappears in the musculature.

Ventral gland not seen, perhaps absent. At the posterior end of the oesophagus (text-fig. 6 D) are two rounded glands, which are formed similarly to the appendage-glands of the oesophagus in *Trilobus* Bastian. Their function may consist in moistening the wall of the intestine.

Intestine.—Cardia indistinct. The intestine has irregularly formed cells in its anterior part. Rectum half anal width.

Tail (text-fig. 6 E, F).—Short, rounded, scarcely one and a half times anal width in length. Glands seem to be absent, but at the posterior end there is a pointed spear-shaped structure (text-fig. 6 F), which can be everted and serves as a holdfast for the nematode. Its base is doubly arched. This spear is connected with a gland-duct, but the gland could not be found. In the posterior region there are some small glands.

Female sexual organs (text-fig. 6 G).—Ovary simple, unpaired; vulva in

the second third of the body, 60·8 per cent. Eggs large, elongate, relatively thin-shelled.

Male unknown.

Habitat.—Ca 985, 1120, 1272.

ACHROMADORA TENAX (de Man).

de Man, 1880, *Cyatholaimus tenax* de Man.

Only one (♀) was found and the specimen agrees so well with the specification given by de Man (12) that the proportional measurements only will be given.

L, 0·556 ; a, 26·7 ; b, 7·6 ; c, 6·2 ; V, 41·1 per cent.

Widths of the oesophagus.—In the anterior end 50 per cent., in its middle 60 per cent., and in its posterior end 66·6 per cent. Bulb 10·4 : 15·6 μ.

Size of the amphids.—2·6 μ, or one-fifth of the corresponding width.

Proportional widths of the body.—44 : 62 (middle of the oesophagus) : 75 : 100 : 94 : 62 : 18.

Habitat.—Ca 1313.

DORYLAIMUS STAGNALIS Dujardin.

Total number.—3 juv. specimens.

Size.—1·612–1·778 ; a, 36–38·5 ; b, 3·8–4·8 ; c, 7·8–12·0.

The three nematodes were too young to be assigned to any of the subdivisions made by Micoletzky (15). They are so selnder that the mature nematode may belong to the group *Dorylaimus stagnalis* subsp. *secundus* v. *multipapillatus* Micol.

DORYLAIMUS FILIFORMIS Bastian f. TYPICUS Micoletzky.

Micoletzky, 1922.

Total number, 3, of which ♀ 1_0 ; ♂ 2 ; sex-number 200.

Size : ♀.		♂.	
L, 1·859		L, 1·833–1·911 (1·872)	2.
a, 47·1		a, 50·3–56·5 (53·4)	
b, 4·9		b, 4·8–5·1 (4·95)	
c, 12·0		c, 64–73·5 (67·75)	
nr, 33·1 per cent.		nr, 23·4–35·5 (33·95) per cent.	
V, 51·5 per cent.			
G_1, 17·9 per cent.			
G_2, 23·3 per cent.			
En, 4			
Es, 26 : 78 μ			

Proportional widths of the body.—

♀. 23 : 73 : 80 : 93(V) : 100 : 53.

♂. 29 : 74 : 93 : 100 : 74. n, 2.

These specimens are identical in structure with those described by de Man (12)

and Micoletzky (15). Nothing can be added. The following measurements may serve for comparison :—

	♀.	♂.
Length of the spear	15·6 μ	13 μ
Thickness of the cuticle	1·9 μ	1·9 μ
Widths of the oesophagus.		
Anterior end	62·5 per cent.	42·9–50 per cent.
Nerve-ring	54·5 per cent.	50 per cent.
Posterior end	58·2 per cent.	53·8–58·3 per cent.
Length of the spicula	....	28·6–34 μ

Habitat.—Ca 388, 1265.

DORYLAIMUS FILIFORMIS Bastian f. TYPICUS Micoletzky sf. ATTENUATUS de Man.

Syn. *Dorylaimus attenuatus* de Man, 1884.

Total number, 2 ♀, of which (1).

Size : ♀.	L, 1·588–2·197 (1·842)	} 2.	V, 43·6–50·2 (46·9) per cent.	} 2.
	a, 40·4–56·3 (48·4)		G_1, 14·8–25·5 (20·1) per cent.	
	b, 5·5–7·6 (6·6)		G_2, 17·5–19·2 (18·8) per cent.	
	c, 11·4–15·3 (13·4)		U_1, 5·3 per cent.	} 1.
	nr, 31·6 per cent.	1.	U_2, 7·1 per cent.	

Proportional widths of the body.—♀. 27 : 73 : 84 : 90(V) : 100 : 43. n, 2.

The present species agrees so well with the description given by de Man (12) that I am almost certain that I have found this form.

The lips are poorly developed. They possess the two circles of papillae mentioned by de Man. These can only be seen with the highest power. The spear is larger than in f. *longicaudatus* ; it is delicate and very thin. Length 18·2–20·8 μ (19·5 μ). The oesophagus enlarges at a point more than half-way down its length. Vulva in the mature female (which has no eggs) a little in front of the middle of the body. Posterior branch of the ovary longer than the anterior. Tail tapering gradually and regularly.

The species is probably to be placed in the group *filiformis* f. *typicus*. It is a subform of this group.

Habitat.—Ca 1264.

DORYLAIMUS FILIFORMIS Bastian f. LONGICAUDATUS (v. Daday).

Syn. *Dorylaimus tenuicaudatus* Bastian, 1865.
Dorylaimus bastiani Butschli, 1873.
Dorylaimus macrurus v. Linstow, 1876.
Dorylaimus longicaudatus v. Daday, 1898.
Dorylaimus pusillus v. Daday, 1905.
Dorylaimus africanus v. Daday, 1910.
Dorylaimus bastiani f. *longicaudatus* (v. Daday) Micoletzky, 1914.

Micoletzky 1922 (15) has already called attention to the great variability of the *filiformis* forms. The variations are best seen in the male. In it the

width of the body varies greatly. I can also state that the number of the praeanal papillæ varies in the male. In my specimens there are from nine to seventeen papillae. The most posterior praeanal papilla is very minute, often hardly noticeable, and always small. In the female also size-variations can be observed, e.g. there are variations in the length of the tail and the relative width of the parts of the body. A table of the measurements shows the variability of the species very well.

Total number, 37, of which ♀ 6, of which 5_0; ♂ 10; juv. 21; sex-number 176.

Size:

♀.		♂.	
L, 1·297–1·988 (1·583)	6.	L, 1·269–1·526 (1·388)	7.
a, 39·7–47·6 (43·6)	6.	a, 35·9–48·9 (41·9)	7.
b, 4·7–5·8 (5·3)	6.	b, 4·7–5·1 (4·9)	7.
c, 11·1–16·9 (14·0)	6.	c, 56–83 (68·1)	7.
V, 42·2–47 (44·8) per cent.	6.	nr, 36·4–39·6 (37·9) per cent.	6.
G_1, 14·9–22·5 (18·3) per cent.	6.	G, 58·5–67·7 (65·1) per cent.	5.
G_2, 15·5–25·7 (21·1) per cent.	6.		
U_1, 5·5 per cent.	1.		
U_2, 13·6 per cent.	1.		
nr, 32·5–34·7 (33·6) per cent.	2.		
En, 2–3	2.		
Es, 20–21 : 65 μ.	2.		

Proportional widths of the body.—
♀. 22 : 72 : 85 : 93 : 100 : 51. n, 6.
♂. 25 : 77 : 92 : 100 : 72. n, 7.

Widths of the oesophagus.

	♀.	♂.
Anterior end	37·5–63·5 (48·6) per cent.	28·6–60·0 (42·7) per cent.
Nerve-ring	40·0–50·0 (44·3) per cent.	40·0–50·0 (47·8) per cent.
Posterior end	50·0–61·5 (55·4) per cent.	45·4–61·5 (51·4) per cent.

Cardia.—10·4–13 μ.
Length of the spear.—♀ 13 μ, ♂ 10·4–13 μ (11·7 μ).
Thickness of the cuticle.—♀ 1·3–1·9 μ (1·7), ♂ 1·3–2·6 μ (1·7 μ).
Length of the spicula.—31–36 μ (35·3 μ).
Habitat.—236, 357, 388, 717, 1272, 1281.

DORYLAIMUS UNIPAPILLATUS v. Daday. (Text-fig. 7.)

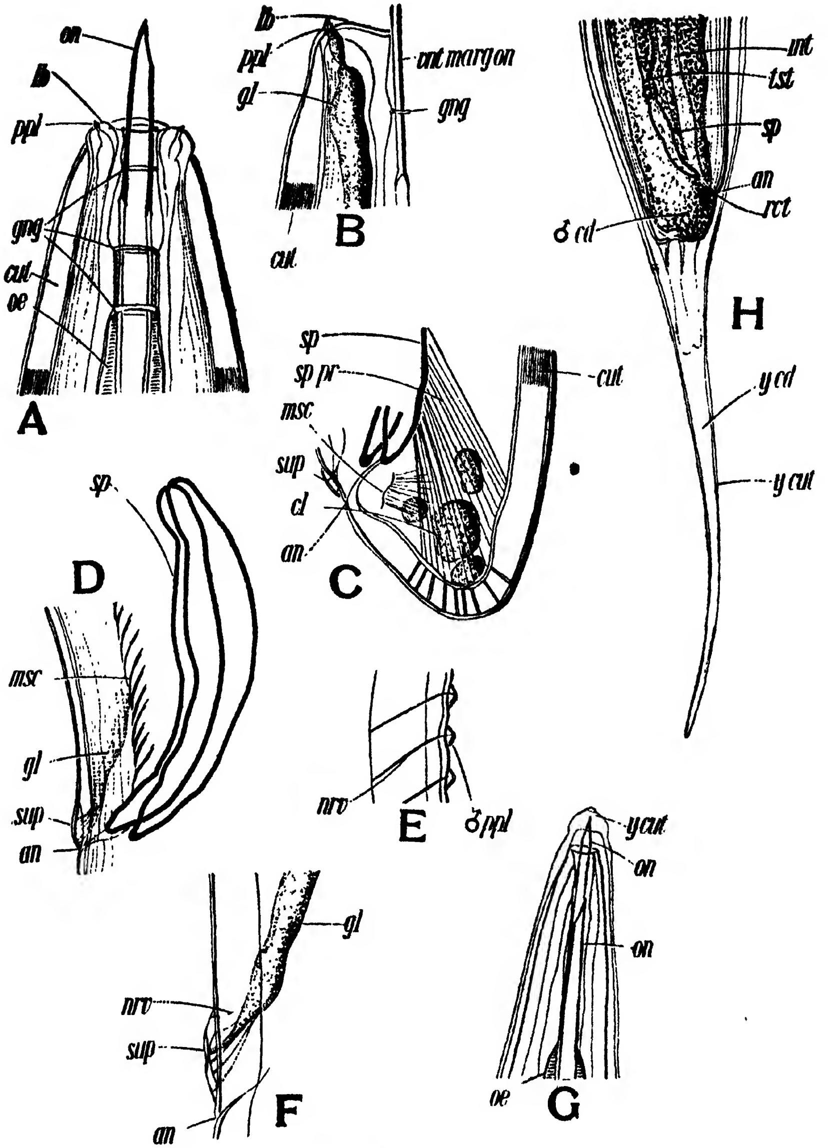
v. Daday, 1905.

Total number, 5, of which ♂ 3, of which (1), juv. 2.

Size: ♂.		Juv. ♂.
L, 4·078–4·953 (4·515)	2.	L, 2·816
a, 22·2–26·1 (24·1)	2.	a, 29·3
b, 4·28–4·56 (4·42)	2.	b, (?).
c, 80·5–100·0 (90·2)	2.	c, 13·7
G, 49·0–50·4 (49·7) per cent.	2.	

Juv.: L, 1·635–1·893: a. 16–24·2: b. 3·4–4·3: c. 7·3–9·5.

TEXT-FIG. 7.



Dorylaimus unipapillatus v. Daday.

A. Anterior end of the male. Oil-im. 1/12, oc. 4. × 900.
B. Development of the ventral papilla in the head of the male. Oil-im. 1/12, K 18. × 1800.
C. Posterior end of the male. The gland-cells, the gland-ducts, and the spicula-protractor can be very easily seen. Oil-im. 1/12, oc. 4. × 900.
D. Spicular apparatus. Oil-im. 1/12, oc. 4. × 900.
E. Praeanal papillae. Oil-im. 1/12, K 18. × 1800.
F. Large praeanal papilla. Oil-im. 1/12, K 18. × 1800.
G. Anterior end of a moulting male. Obj. D, oc. 5. × 600.
H. Posterior end of a moulting male. The male tail has already changed. The connections with the cuticle of the juvenile tail are

Proportional widths of the body.—♂. 16 : 15 (constriction behind the lips) : 71 (middle of the oesophagus) : 97 : 100 : 35. n, 2.

Body.—Plump. The anterior end is $\frac{2}{11}$ of the width at the posterior end of the oesophagus and one-sixth of the largest width of the body. The body is more tapered than in the specimens of v. Daday.

Cuticle.—Markedly thick : 5·2–7·8 μ. The exterior layer is smooth, the second layer has a distinct longitudinal striation. The number of the striae is twelve. At the tail (text-fig. 7 C) the cuticle is thickened, being in one male 10·4 μ and in the other 13 μ thick. The structure at the posterior end is described below.

Head (text-fig. 7 A, B). The anterior end is sharply cut off ; six well-developed lips, like those shown in the figure of v. Daday. Consequently it is puzzling that he does not mention the lips. On each lip is a bristle-shaped papilla. Each papilla has a gland-duct (text-fig. 7 B), the posterior end of which ends in an elongate gland. Probably these glands are connected with the oesophagus. Although I used an oil-immersion lens, the posterior circle of papillae, which v. Daday claims to have seen, was not found. The spear is large and strong, 55–57·2 μ long. It projects from the front end of the lumen of the oesophagus, as in *Actinolaimus tripapillatus* (v. Daday). The spear of both species has a furcate posterior end. The wall of the guide-tube of the spear has a slight indication of the 'Querringe', but these I believe to be indications rather of shrinking than of definite cuticular formations. Only the most anterior ring, the intermediate, and the most posterior are visible.

Oesophagus.—Originates at a distance from the anterior end of the head equal to two and a quarter times the width of the head at this point. Anteriorly the oesophagus is narrow ; it swells visibly only in the last third. Width at the anterior end 28 per cent. ; in the middle 37·5–43·4 (40·4) per cent., and at the posterior end 36·9–42·4 (39·7) per cent. Nerve-ring at about the middle of the oesophagus.

Cardia.—Large, but without cuticular reinforcements : 13–39 : 28·6–52 μ.

Tail (text-fig. 7 C).—Short, rounded, truncate, tapering uniformly on the ventral and dorsal side. Within it several gland-cells of different sizes were seen. Perhaps these are degenerate tail-glands. They show the structure of the cuticle of the tail. At the posterior end 8–9 very fine and small ducts are to be seen, which must be the secretory ducts of glands. The anal musculature, which v. Daday saw, is also present.

Male sexual organs (text-fig. 7 C–F).—Testis elongate, its length nearly equal to half the body-length : 49–50·4 per cent. Spicula slightly curved ; its form corresponds comparatively well to the description of v. Daday. Proximal end rounded, not enlarged as contrasted with the anterior end, which swells belly-shaped. The distal end is pointed. Size 109·2–114 μ. The praeanal musculature is well developed and extends anteriorly beyond the praeanal row of papillae. The spicula-protractor (text-fig. 7 C, *sp pr*) lies in the tail.

Praeanal armament.—Considerably in advance of the anus there begins a row of 28–30 very small papillae, close together. The anterior end of the row is 4½, the posterior end 2, anal widths in front of the anus. Each papilla is slightly elevated and connected with a nerve-fibre (text-fig. 7 E). Because of the minute size of the papillae, I was unable to see their exact structure. Immediately in front of the anus there is a large papilla (text-fig. 7 F), which is slightly arched and has a distinct gland-duct, the course of which could not be followed in the musculature. The papilla has numerous nerve-fibres, and therefore I conclude that it serves as an organ of touch and feeling.

It is of interest to note that the development agrees with that of *Actinolaimus tripapillatus* (v. Daday). The young agamic nematode (text-fig. 7 H) has a long tail like that of the female. No females were found. In the course of its development it loses its long tail as it becomes a mature male. Text-fig. 7 G shows the development of the second spear during a moult.

We must accept this as the species described by v. Daday. The various inaccuracies which have crept into his description are not sufficiently important to warrant the establishment of a new species.

Habitat.—Ca 390, 1117, 1120, 1129, 1153.

DORYLAIMUS PARAGUAYENSIS, sp. n. (Text-fig. 8.)

Total number, 93, of which ♀ 25, of which 1_0 ; ♂ 30 ; juv. 38 ; sex-number 120.

Size : ♀.	L, 0·806–0·970 (0·869)	7.	L, 0·712–0·868 (0·801)	6.
	a, 26·3–32·1 (30·3)		a, 25·7–28·8 (27·9)	
	b, 4·3–5·5 (5·0)		b, 4·3–5·2 (4·7)	
	c, 8·8–10·6 (9·5)		c, 42·8–52·8 (47·8)	
	V, 39·2–58·3 (45·4) per cent.		G, 61·2–66·8 (63·3) per cent.	
	nr, 44·7–55·2 (49·9) per cent.	2.	nr, 41·8–50·0 (46·0) per cent.	4.
	G_1, 14·2–17·3 (15·9) per cent.	4.		
	G_2, 14·1–20·5 (16·3) per cent.			
	En, 2	1.		

Proportional widths of the body :—

♀. 27 : 87 : 92 : 95(V) : 100 : 53. n, 7.

♂. 24 : 83 : 92 : 100 : 64. n, 6.

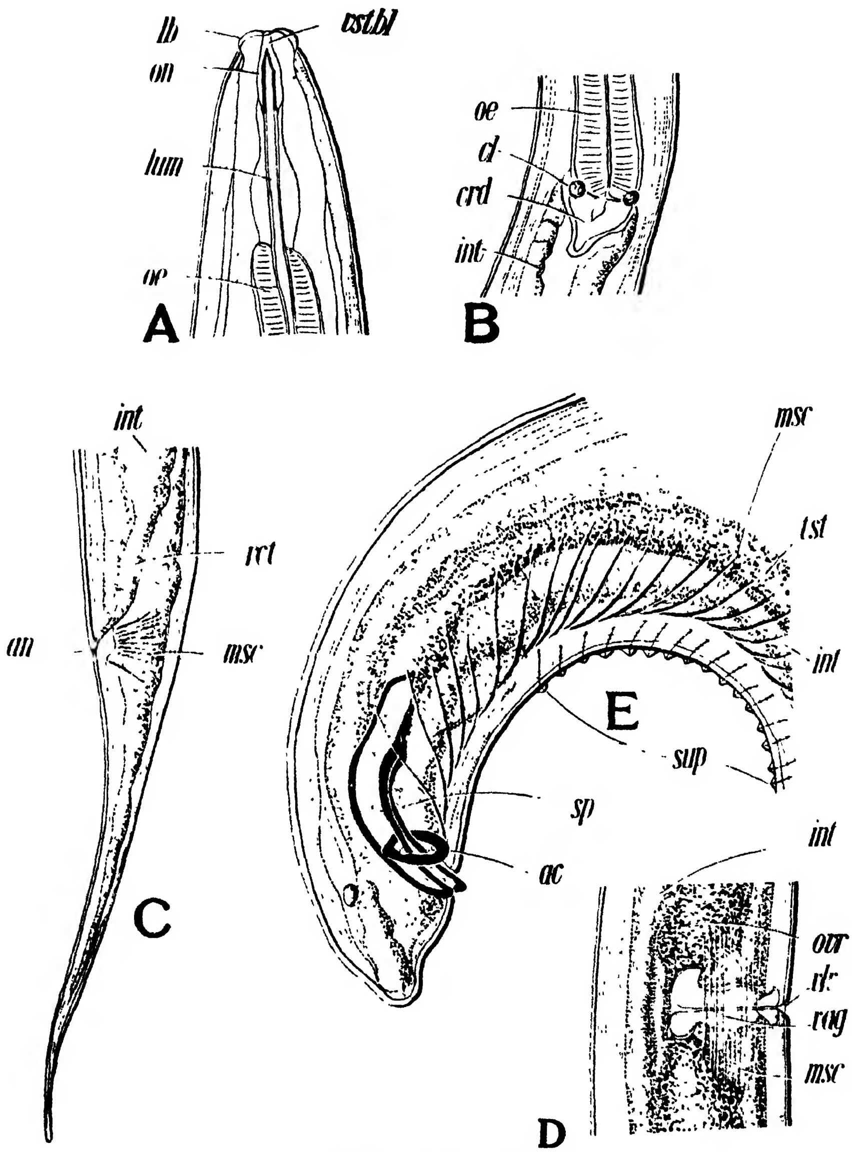
Body.—Not very slender, small ; its anterior end nearly one-fourth of the maximum width of the body. Posterior end in the female elongate, in the male rounded, truncate.

Cuticle.—Smooth, thin, exterior layer very delicate. Thickness : ♀ 0·9–1·3 μ (1·1 μ), ♂ 1·3–1·9 μ (1·4 μ).

Anterior end (text-fig. 8 A).—Very much reduced. Lips very slightly developed, without papillae. Spear short, simple, not furcate at its posterior end. Length : ♀ 7·8–10·4 μ (9·3 μ), ♂ 7·8–13 μ (10·2 μ).

Oesophagus (text-fig. 8 B).—The anterior end relatively narrow. The posterior end is bulb-shaped, but cannot be described as a true bulb. The

TEXT-FIG. 8.



Dorylaimus paraguayensis, sp. n.

A. Anterior end of the male. Oil-im. 1/12, K 18. ×1800.
B. Posterior end of the oesophagus in the female. Oil-im. 1/12, oc. 4. ×900.
C. Posterior end of the female. Oil-im. 1/12, oc. 5. ×1350.
D. Structure of the vulva. Oil-im. 1/12, oc. 5. ×1350.
E. Posterior end of the male. Oil-im. 1/12, K 18. ×1800.

oesophagus originates at a distance from the anterior end equal in the female to 2·25–4 (3·15) and in the male to 2·5–4 (3·3) times the width of the head at the point of origin. Width at the anterior end: female 40–61·2 (45·9) per cent.; male 37·5–50 (42·9) per cent.; at the nerve-ring 36·4–50 (43·4) per cent. resp. 40–55·5 (48·5) per cent.; and at the posterior end 45·4–66·6 (53·9) per cent. resp. 50–60 (53·3) per cent. Nerve-ring about the middle of the oesophagus. Where the oesophagus meets the cardia, there are two small glands.

Cardia.—Very large and voluminous, without cuticular reinforcements. Female 10·4–13 (10·9) : 13 μ, male 7·8–13 (11·1) : 9·1–15·6 (12·7) μ. Rectum= 2 anal widths.

Tail (text-fig. 8 C, E).—In the female elongate, gradually reduced without becoming filiform; with a well-developed anal musculature; in the male short, conical, and has, not only dorsally but also ventrally, a distinct indentation in front of its posterior end. The cuticle is a little thickened at the posterior end. Tail-glands absent or at most vestigial.

Female sexual organs.—Ovary paired, symmetrical, reflexed. Vulva (text-fig. 8 D) variable in position, being found anterior and posterior to the middle of the body. It is sunk in the body. Vagina with two cavities, with a distinct septum.

Male sexual organs (text-fig. 8 E).—Testis elongate, simple. The anterior end of the spicula very curved; proximal end cut off obliquely, distal end open. The two spicula-margins do not grow together. Length 28·6–36 μ (32·6 μ). A simple gubernaculum is present, plate-shaped in form. It is a little in front of the distal end of the spicula. Size one-fourth spicula-length. The praeanal armament consists of a row of fifteen to sixteen very small papillae, which are close together. The anterior end of the row is 3½–4, the posterior end 1¼–1½ anal widths anterior to the anus.

Affinities.—The present species is closely related to *Dorylaimus filiformis* f. *longicaudatus* (v. Daday) (Micoletzky, 15). The differences between the two species are as follow:—

(1) The anterior end of the present form has slight lips and a short spear;

(2) The body is shorter than in the other species;

(3) The structure of the spicular apparatus is different;

(4) In the tail there are no subdorsal papillae, which seem to be typical of the species *filiformis* (Micoletzky, 15).

Perhaps the present species is a subspecies of *Dorylaimus filiformis*, but it is likely that it is a new species, since its male sexual organs are different in structure.

Habitat.—Ca 1146.

DORYLAIMUS ANNULATUS v. Daday. (Text-fig. 9.)

v. Daday, 1905.

Total number, 3, of which ♀ 1, juv. 2.

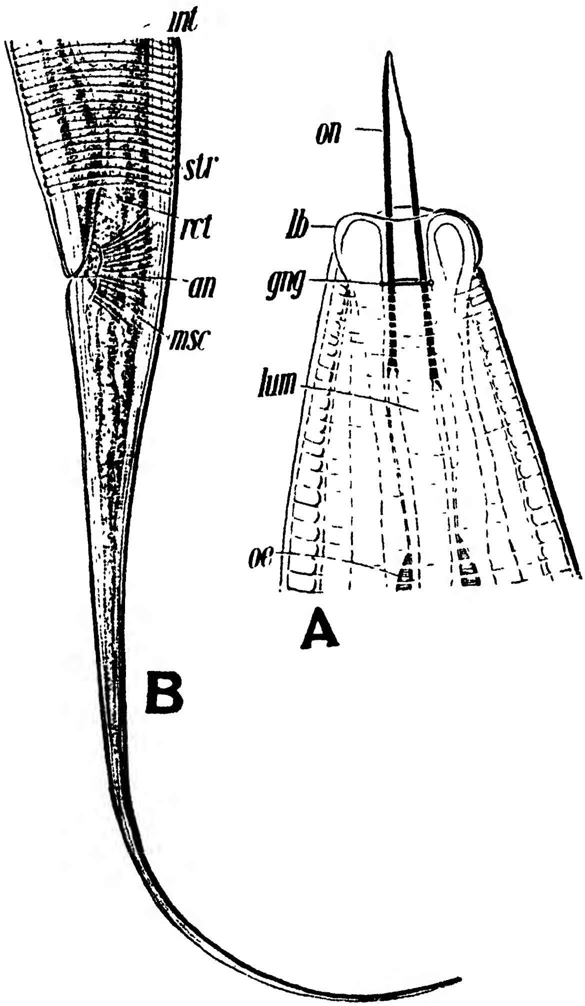
Size.—♀. L, 3·279; a, 31·6; b, 4·5; c, 10; V, 42·4 per cent.

Proportional widths of the body.—

♀. 15 : 12 (constriction behind the lips) : 65 : 92 : 98(V) : 100 : 22.

One female of the species, of which v. Daday has described the male, was found. The female chiefly differs from the other sex in having a differently shaped tail. Male not found.

TEXT-FIG. 9.



Dorylaimus annulatus v. Daday.

A. Anterior end of the female. Oil-im. 1/12, K 18. ×1800.

B. Posterior end of the female. Obj. D, oc. 5. ×600.

Body.—Anterior end one-sixth of the width at the posterior end of the oesophagus ; posterior end elongate, nearly filiform.

Cuticle.—In two layers. Exterior layer thin, smooth; inner layer thick and distinctly striated. The annulation begins just behind the lips and disappears gradually in the tail. Thickness 5·2 μ.

Head (text-fig. 9 A).—Anterior end set off slightly. The lips are small and not conspicuous. Papillae not seen. Spear large, strong; its posterior end is furcate. Length 39 μ. Only one ganglion-ring, situated just behind the constriction. Cuticular transverse rings seem to be absent.

Oesophagus.—Normal. Width at the anterior end 30·3 per cent.; at the nerve-ring 38·5 per cent., and at the posterior end 48·6 per cent. The nerve-ring lies slightly behind the anterior fourth of the oesophagus (27·9 per cent.), and at this point the oesophageal enlargement begins.

Cardia and intestine.—Of regular form. Rectum = 2 anal widths.

Tail (text-fig. 9 B).—Very much elongate, posteriorly becoming filiform, longer than ten anal widths. The anal musculature is very well developed. Tail-glands vestigial, only indicated.

Female sexual organs.—Regular form. Vulva just anterior to the middle of the body, 42·4 per cent.

Habitat.—Ca 1270, 1281.

Dorylaimus homalopapillatus,* sp. n. (Text-fig. 10.)

Total number, 8, of which ♀ 5, of which 3_0 and (1); ♂ 3; sex-number 60.

Size: ♀.		♂.	
L, 2·062–2·675 (2·406)	5.	L, 1·924–2·298 (2·152)	3.
a, 24·4–33·0 (28·5)		a, 25·9–27·3 (26·6)	
b, 4·3–5·1 (4·7)		b, 4·3–4·55 (4·4)	
c, 10·0–12·8 (11·0)		c, 74·0–86·0 (80·0)	
V, 42·7–49·4 (45·2) per cent.		nr, 31·6–37·7 (33·6) per cent.	
G_1, 16·7–20·5 (18·1) per cent.	4.	Ca, 13–15·6 : 15·6–23·4 μ (14·7 : 19 μ)	
G_2, 20·1–24·6 (22·4) per cent.			
U_1, 7·4–14·2 (10·7) per cent.	2.		
U_2, 10·5–17·8 (14·2) per cent.			
En, 2–8 (5)	3.		
Es, 26–31 : 60–68 μ (29 : 63 μ)			
Ca, 13–16 : 18·2–26 μ (14·9 : 21·7 μ)			

Proportional widths of the body.—

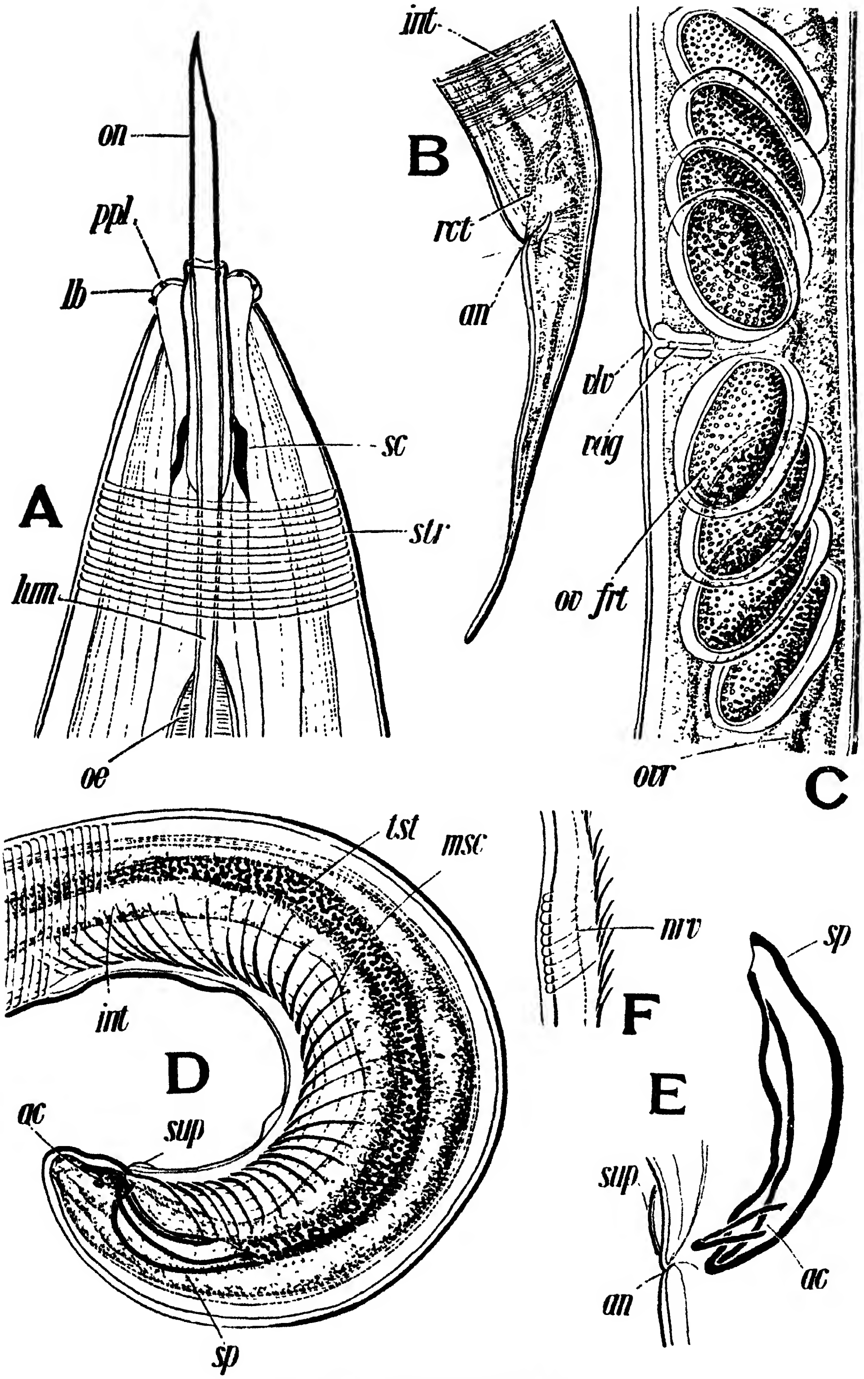
♀. 15 : 67 : 88 : 93(V) : 100 : 34. n, 5.

♂. 15 : 63 : 84 : 100 : 43. n, 3.

Body.—Plump, anterior end one-sixth as wide as the maximum width of the body. Posterior end in the male short and rounded; in the female elongate.

Cuticle.—In two layers, thick: female 3·9–4 μ (3·9 μ), male 3·9–9·9 μ (6·5 μ). The outer layer is very thin, the inner thick with a distinct annulation similar to that in *Dorylaimus annulatus* v. Daday (7). The annulation begins just behind the constriction of the head and ends at the posterior end of the tail.

* ὁμαλός, flat, plain.



Dorylaimus homalopapillatus, sp. n.

A. Anterior end of the female. Oil-im. 1/12, K 18. ×1800.
B. Posterior end of the female. Oil-im. 1/12, oc. 1. ×450.
C. Structure of the vulva. Oil-im. 1/12, oc. 1. ×450.
D. Posterior end of the male. Obj. D, oc. 5. ×600.

At the posterior end of the male (text-fig. 10 D) the annulation of the cuticle is only visible on the dorsal side, and shades off gradually towards the posterior end of the body.

Anterior end (text-fig. 10 A).—Six prominent lips, which bear two circles of papillae. Both circles are of the same size. The lips are well set off. Spear large, lying in a distinct tube. Length of the spear: female 28·6–31·2 μ (29·1 μ), male 23·4–28·6 μ (26·9 μ). The tube of the stylet has a cuticular reinforcement, which lies a distance from the anterior end of the body of one and a half times the width of the anterior end. Probably this apparatus serves to prevent the spear from slipping. The posterior end of the spear is furcate. No connections between the papillae of the lips and the oesophagus were visible.

Oesophagus.—Narrow in front, then suddenly enlarged just behind its middle. Its origin lies in the female a distance of three to five times the width of the anterior end of the body from the anterior end; in the male 3·5–5 times this width. Width at the anterior end: female 28·5–41·6 (35·5) per cent.; male 26·7–40 (34·3) per cent.; at the nerve-ring (in the female at the middle of the oesophagus) 35–47·7 (41·4) per cent. resp. 36·3–46·6 (42·8) per cent., and at the posterior end 44·4–50 (46) per cent. resp. 44·9–55 (48·9) per cent. Nerve-ring at the end of the first third of the oesophagus; not seen in the female, which was darkly coloured.

Cardia.—Large, voluminous (measurements above). Intestine in the female darkly coloured. Rectum $=1\frac{1}{2}$ anal widths, or a little more.

Tail (text-fig. 10 B, D).—In the female (text-fig. 10 B) at first conical, then elongate, but not filiform. Length of the cone-shaped part of the tail one-fourth of the whole length of the tail. The tail of the male (text-fig. 10 D) is short, dorsally strongly curved, ventrally straight. Posterior end rounded with a thickened cuticle.

Female sexual organs.—Ovary paired, slightly asymmetrical, reflexed. The anterior branch is shorter than the posterior. Vulva in front of the middle of the body. Vagina in two divisions, sunk below the surface one-third of the width of the body. Number of eggs up to eight. The eggs have a thick shell and are placed one above the next, as in *Actinolaimus tripapillatus* (v. Daday) (text-fig. 10 C). The length of the ovary, the position of the vulva, and the size of the eggs are given above.

Male sexual organs.—Testis not seen, because the specimens were darkly coloured. Probably it is normally developed. Spicula (text-fig. 10 E) very slightly curved. Proximal end slanting, distal end sharply rounded. Ventrally and in the interior there is a strengthened margin which serves as a reinforcement. Length 47–55 μ (51 μ) or 2 anal widths. The gubernaculum lies just in front of the distal end of the spicula. It has the form of an acute-angled triangle. It is small, less than one-fourth of the length of the spicula. The praeanal armament (text-fig. 10 D) consists of three papillae, which are flat. The most anterior papilla is not quite 4 anal widths, the second $1\frac{1}{2}$ anal widths in front of the anus, and the most posterior is just in front of the anus.

Their structure (text-fig. 10 F) is the same as in *Actinolaimus tripapillatus* (see text-fig. 11 K). They are slightly elevated, and have in the interior nerve-fibres, which have no swellings.

Affinities.—The differences from *Dorylaimus annulatus* v. Daday are :—

(1) The smaller size of the body (female 2·406, male 2·152, compared with 3·279 amd 5 mm.) ;

(2) The existence of a scaffold in the guide-tube of the spear, which is absent in *D. annulatus* ;

(3) The different structure of the spicular apparatus, and, above all, the existence of only three praeanal papillae, whereas thirty-seven small papillae are present in *D. annulatus*.

Habitat.—Ca 388, 718, 1266.

ACTINOLAIMUS TRIPAPILLATUS (v. Daday). (Text-fig. 11.)

Syn. *Dorylaimus tripapillatus* v. Daday.

Total number, 102, of which ♀ 13, of which 3_0 ; ♂ 48, of which (12) ; juv. 41 ; sex-number 277.

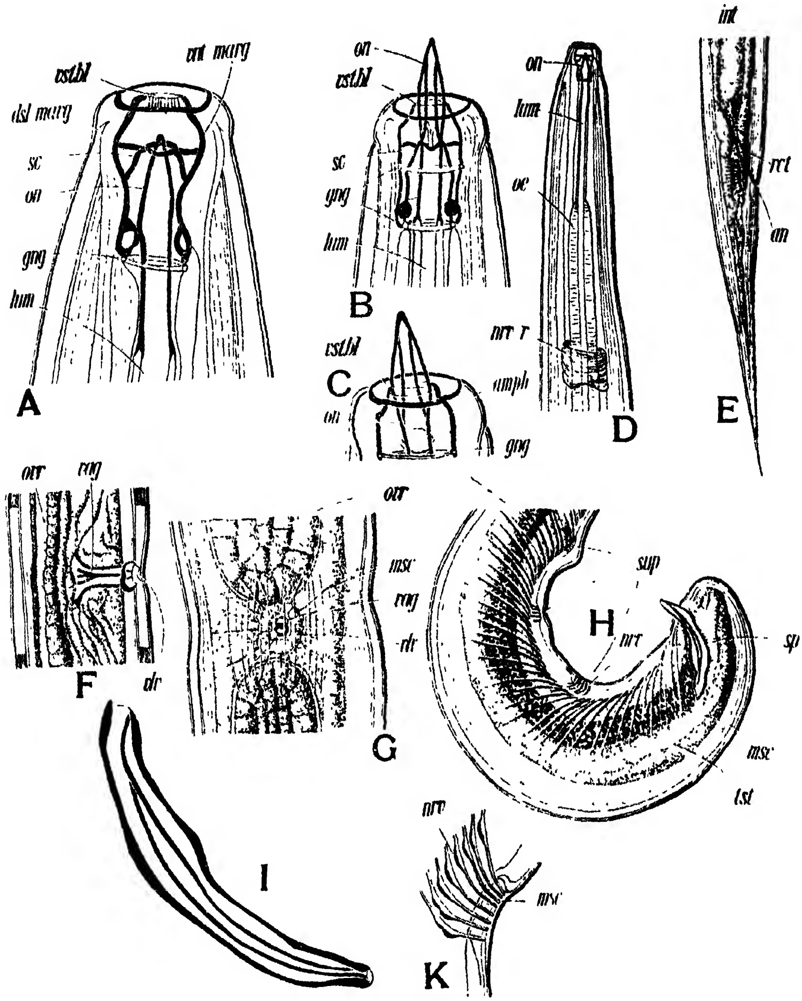
Size : ♀.	L, 4·05–8·73 (6·118)	13.	♂. L, 4·68–9·045 (6·554)	36.
	a, 58–73·2 (65·7)		a, 52·6–77·9 (66·8)	
	b, 4·78–7·08 (5·74)		b, 4·15–6·34 (5·45)	
	c, 17·2–25·3 (20·9)		c, 125–195 (164)	
	V, 23·5–35·2 (29·3) per cent.		nr, 11·9–13·7 per cent.	
	nr, 11·9–13·6 per cent.			

Juv. : L, 2·28–5·295 (3·639) ; a, 46·2–66·7 (58·1) ; b, 3·88–5·87 (4·72) ; c, 10·8–20·7 (14·9). n, 41.

A detailed description of this species was given in the paper, ‘ Die Entwicklung von *Actinolaimus tripapillatus* (v. Daday) ’, Ztschr. für Morphologie und Ökologie der Tiere, A, xviii, 1930. Here we will give only a short specific diagnosis, the sizes, and figures.

In both sexes the anterior end of the body is about 1/4·5 times as wide as the maximum width of the body. Tail of the female elongated, pointed ; tail of the male truncated, rounded. The pharynx has a very strongly developed framework, and is narrower in the female than in the male (15·6–18·2 : 28·6–31·2 μ resp. 15·6–16·9 : 28·6–31·2 μ). The spear is truncated, pointed at the anterior end. There is a subcuticular margin on each side of its anterior half in the female. Posterior end furcate. Supporting scaffold of the spear present. Length of the spear : female 39–41·6 μ, male 36·4–39 μ. Just in front of the spear-scaffold are the circular amphids. The oesophagus begins three spear-lengths behind the base of the pharynx. Nerve-ring in the first third of the the oesophagus. Width at the anterior end: female 27·3–34·8 per cent. (15·6–20·4 μ), male 28·5–31·5 per cent. (15·6–18·2 μ) ; at the nerve-ring 26·9–37·5 per cent. (18·2–31·2 μ), resp. 24·1–34·5 per cent. (18·2–26 μ), and at the posterior end 43·8–52·7 per cent. (36·4–52 μ), resp. 41–50 per cent. (39–46·8 μ). Cardia large and triangular, 26–28·6 : 31·2–36·4 μ.

TEXT-FIG. 11.



Actinolaimus tripapillatus (v. Daday).

A. Anterior end of the male.
B. Anterior end of the female.
C. Extreme anterior end of the female.
D. Structure of the nerve-ring in the male.
E. Posterior end of the female.
F. Structure of the vulva. Lateral view.
G. Structure of the vulva. Ventral view.
H. Posterior end of the male.
I. Spicula.
K. Praeanal papilla.

Female sex-organs.—Ovaries asymmetrical. Vulva far forward. Posterior branch of the ovary elongate. Eggs large and thick-shelled.

Male sex-organs.—Testis elongate, paired, not reflexed. Spicula slightly curved, 96·2–117 μ long. Their proximal and distal ends are round. No accessory piece. Three praeanal papillae, the most anterior being the least developed.

Proportions at the posterior end.—Length of the tail, female 4·7–6·1, male 0·54–0·66; spicula 1·46–2·14; distance, anus to 1st papilla 3·34–4·66, anus to 2nd papilla 2·38–3·33, anus to 3rd papilla 1·66–1·9.

Widths of the body.—Anterior end: female 23·4–26 μ, male 20·8–26 μ; anterior end of oesophagus 52–59·8 μ resp. 49·4–62·4 μ, nerve-ring 65–83·2 μ resp. 62·4–75·4 μ, posterior end of the oesophagus 83·2–101·4 μ resp. 83·2–106·6 μ, largest width (in the middle of the body) 78–119·6 μ resp. 88·4–117 μ, vulva 78–109·2 μ, anus 46·8–52 μ resp. 54·6–67·6 μ.

Habitat.—Ca 182, 263, 357, 388, 717, 719, 1126, 1222, 1224, 1265, 1267, 1272, 1282.

Abbreviations.

ac. Accessory.
amph. Amphid.
an. Anus.
apnd. Appendix.
apph. Apophysis.
cd. Cauda.
cl. Cell.
crd. Cardia.
cut. Cuticula.
dsl. Dorsal.
gl. Gland.
gng. Ganglion.
grn. Granula.
int. Intestine.
lb. Lip.
lum. Lumen.
marg. Margin.
msc. Muscle.
nrv. Nerve.
nrv r. Nerve-ring.
oe. Oesophagus.
on. Onchus, tooth, spear.
ovr. Ovary.
ov frt. Fertilized egg.
ph. Pharynx.
ppl. Papilla.
pr. Protractor.
rct. Rectum.
sc. Scaffold.
set. Seta.
sp. Spicula.
spn. Spinneret.
sp pr. Spicula protractor.
str. Striae.
sup. Supplementary.
tst. Testis.
ut. Uterus.
vag. Vagina.
vlv. Vulva.
vnt. Ventral.
vstbl. Vestibulum.
y. Young.

References.

(Only the papers which have been cited in the text.)

(1) Bastian, C. H. Monograph on the Anguillulidae or Free Nematoides, Marine, Land, and Freshwater. Trans. Linn. Soc. London, xxv, 1865.

(2) Bütschli, O. Beiträge zur Kenntnis der freilebenden Nematoden. Nova Acta Leop.-Carol. xxxvi, 1873.

(3) Cobb, N. A. Nematodes, mostly Australian and Fijian. Macleay Mem. Vol., Dept. Agric. N.S.W. Miscell. Publ. xiii, 1893.

(4) COBB, N. A. Plant Diseases and their Remedies; Diseases of the Sugar-Cane. Agr. Gaz. 1893.

(5) ——. North American Free-living and Freshwater Nematodes. Contr. to a Sc. of Nematology, ii, 1914.

(6) v. DADAY, E. Die freilebenden Süsswassernematoden Ungarns. Zool. Jahrb. Syst. x, 1898.

(7) ——. Untersuchungen über die Süsswasser-Mikrofauna Paraguays. Zoologica, xviii, 1905.

(8) ——. Untersuchungen über die Süsswasser-Mikrofauna Deutsch-Ostrafrikas. Ibid. xxiii, 1910.

(9) HOFMÄNNER, B., u. MENZEL, R. Die freilebenden Nematodon der Schweiz. Rev. Suisse de Zool. xxiii, 1915.

(10) KREIS, H. A. Die Entwicklung von *Actinolaimus tripapillatus* (v. Daday). Ein Beitrag zur postembryonalen Entwicklung der freilebenden Nematoden. Ztschr. f. Morph. u. Oek. der Tiere, A, xviii, 1930.

(11) v. LINSTOW, O. Helminthologische Beobachtungen. Arch. f. Naturg. xlii, 1876.

(12) DE MAN, J. G. Die frei in der reinen Erde und in süssen Wasser lebenden Nematoden der niederländischen Fauna, 1884.

(13) MICOLETZKY, H. Freilebende Süsswasser-Nematoden aus den Ostalpen, mit besonderer Berücksichtigung des Lunzer Seengebietes. Zool. Jahrb. Syst. xxxvi, 1914.

(14) ——. Freilebende Süsswasser-Nematoden der Bukowina. Ibid. xl, 1917.

(15) ——. Die freilebenden Erdnematoden. Arch. f. Naturg. Abt. A, 1921.

(16) ——. Die freilebenden Süsswasser- und Moornematoden Dänemarks. Mém. Acad. Sc. et Lettres de Danemark. Sect. Sc. 8me S. x. 1925.

Report on the Scorpions collected by Mr. Bertram Thomas in Arabia. By

SUSAN FINNEGAN, B.Sc., Ph.D., Assistant Keeper in the Department of Zoology, British Museum (Natural History).

(With 8 Text-figures)

[Read 18 February 1932]

THE number of species in this collection is small—there are six species, *Nebo hierochonticus* representing the family Scorpionidae, while the rest all belong to the family Buthidae.

The route selected by Mr. Thomas was from Salala to Doha and led first through the Qara Mountains on the coast and then across the Great Arabian Desert. A few of the specimens were obtained in the mountainous area, but these all belong to the species *Nebo hierochonticus*, the remainder from the desert being Buthids. The geographical range of the species collected is restricted to Syria, Palestine, Mesopotamia, Arabia, Persia, the coasts of the Red Sea, Algeria, Egypt, and as far south as Abyssinia on the African side.

Family SCORPIONIDAE.

Subfamily DIPLOCENTRINAE.

Genus NEBO.

NEBO HIEROCHONTICUS (Simon).

Hemiscorpio hierochonticus Simon, Ann. Soc. Ent. Fr. (5) ii, 1872, p. 255.
Nebo hierochonticus Simon, Ann. Soc. Ent. Fr. (5) viii, 1878, p. 399 ; Kraepelin, Das Tierreich, Berlin, Lief. viii, 1899, p. 98.

Gurthunut, Qara Mountains, 12. ii. 1930. Alt. 2,950 feet. Coll. nos. 52, 57, 64.

Ain, Qara Mountains, 8. xi. 1930. Alt. 1,500 feet. Coll. nos. 202, 203, 204, 206.

Khiyunt, 10. xi. 1930. Alt. 1,750 feet. Coll. no. 226.

Fuzul, 16. xi. 1930. Alt. 1,350 feet. Coll. no. 346.

Family BUTHIDAE.

Subfamily BUTHINAE.

Genus BUTHUS Leach.

BUTHUS QUINQUESTRIATUS (Hemprich & Ehrenberg).

Androctonus (*Liurus*) *quinquestriatus* Hemprich & Ehrenberg, Symbolae physicae, Arachnoidea, ix, 1831 (pls. 1828), no. 1, t. 1, fig. 5, sign *a*.
Buthus quinquestriatus Kraepelin, Jahr. hamburg. wiss. Anst. viii, 1891, p. 200 Kraepelin, Das Tierreich, Berlin, Lief. viii, 1899, p. 27.

Wadi Ghabartan, 9. ii. 1930. Alt. 1860 feet. Coll. nos. 45 & 46.

Ain al Riqat. Alt. 250 feet, 2. xi. 1930, Coll. no. 115. 4. xi. 1930, Coll. no. 139.

BUTHUS CRASSICAUDA (Olivier).

Scorpio crassicauda Olivier, G. A., Voyage dans l'Empire Ottoman, l'Egypte et la Perse, v, 1807, p. 171, t. 42, fig. 2.

Buthus crassicauda Kraepelin, Das Tierreich, Berlin, Lief. viii, 1899, p. 16.

Binkhauter, 24. i. 1930. Alt. 720 feet. Coll. no. 20.

Kharaiyim Fasao, 20. xii. 1930. Alt. 850 feet. Coll. no. 426.

BUTHUS ACUTECARINATUS Simon.

Buthus acutecarinatus Simon, Ann. Mus. Stor. nat. Genova, xviii, 1883, p. 245, t. 8, fig. 18; Kraepelin, Das Tierreich, Berlin, Lief. viii, 1899, p. 18.

Milwah al 'Aud, 1. xi. 1930. Alt. 220 feet. Coll. no. 85.

Doda, 10. i. 1931. Alt. 900 feet. Coll. no. 460.

Genus MICROBUTHUS Kraepelin.

MICROBUTHUS PUSILLUS Kraepelin.

Microbuthus pusillus Kraepelin, Mitt. naturh. Mus. Hamburg, xv, 1898, p. 42; Das Tierreich, Berlin, Lief. viii, 1899, p. 38.

Milwah al 'Aud, 30. x. 1930. Alt. 220 feet. Coll. no. 15.

Genus APISTOBUTHUS, gen. nov.

Tarsal spur reduced to a small weak spine, sometimes present on the fourth pair, always absent on the third pair of legs. Immovable fang of mandible with two spines on lower margin. Dentition of fingers of cheliped consisting of thirteen rows of median teeth, last tooth of median series greatly enlarged; outer and inner series consisting of single teeth placed, in the outer series, slightly posterior to the level of the enlarged median tooth, and in the inner series about the level of the middle of the median series. Cephalothorax with postocular portion depressed; ante-ocular portion rising steeply to level of anterior margin. Keels finely tuberculated, surface minutely granular. Deep ⊥-shaped sulcus behind ocular tubercle. Sternum triangular, one and a half times longer than broad, with incised median groove. Abdomen distinctly three-keeled. First three segments of tail region flattened, the second expanded laterally. No spine beneath aculeus.

Genotype, *Apistobuthus pterygocercus*, sp. n.

APISTOBUTHUS PTERYGOCERCUS, sp. n.

Uruq Dhahiqah, 26. xii. 1930. Alt. 700 feet. Coll. no. 446.

Shena. 4. i. 1931, alt. 1,000 feet. Coll. no. 452. 5. i. 1931, alt. 1,000 feet, Coll. no. 456.

Colour ochraceous-yellow, lateral eyes black, ocular tubercle infuscate, teeth on fingers of chelipeds, tips of mandibles, claws, and aculeus light brown.

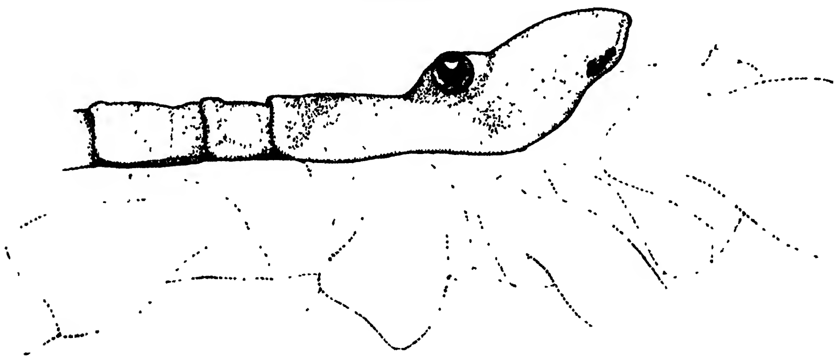
Anterior margin of *cephalothorax* straight and at higher level than ocular tubercle (text-fig. 1). Posterior portion of cephalothorax depressed, deep

⊥-shaped sulcus behind ocular tubercle (text-fig. 2). Surface minutely granular, keels finely tuberculated; posterior keel curving round to meet the lateral keel, which is indicated faintly by a row of granules. Median keels barely distinguishable; anterior keels extending a very little distance beyond the ocular tubercle.

Median *eyes* large, placed midway between anterior and posterior margins of cephalothorax. Five lateral eyes, three large eyes, fourth and fifth small, each about one-third diameter of the larger eye (text-fig. 3).

Sternum triangular, one and a half times longer than broad with deep median cleft extending one-third length of the plate (text-fig. 4).

TEXT-FIG. 1.

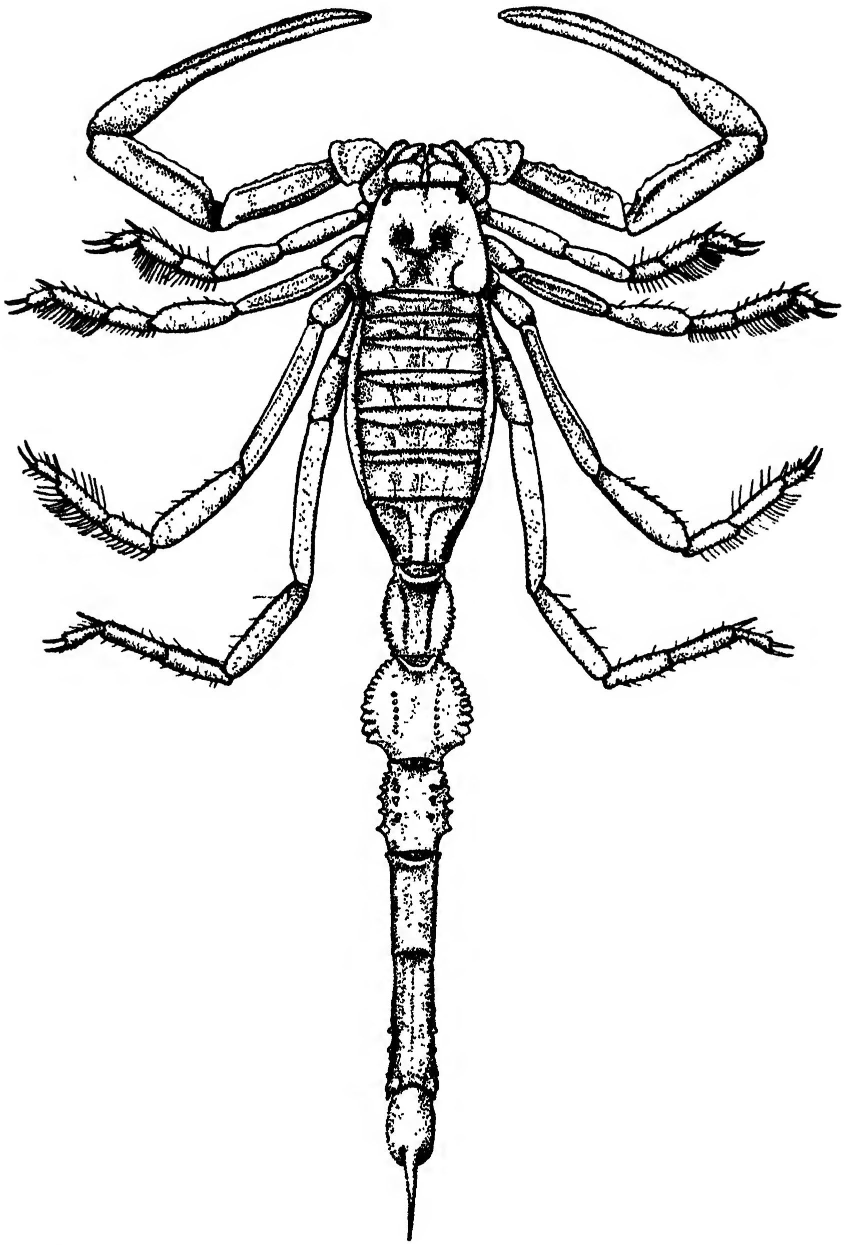


Apistobuthus pterygocercus, sp. n. Lateral view of cephalothorax. ×9.

First two abdominal *terga* with median keels distinct, lateral keels short and curved back upon themselves, third, fourth, fifth, and sixth tergites with three keels; seventh tergite with well-defined median keel on anterior half of segment, four sharply tuberculated lateral keels, the two keels on either side joined to each other anteriorly and forming a continuous loop, one on each side of the median keel. *Sterna* smooth and shining, the last one with four keels, penultimate with indication also of two median and two short lateral crests.

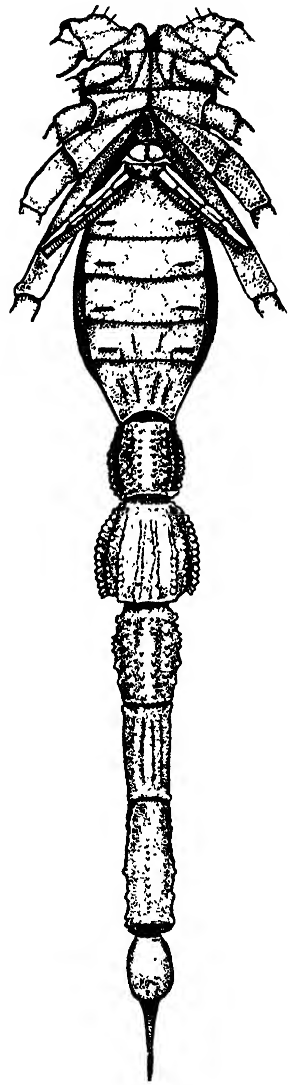
Tail very much flattened anteriorly, first segment deeply excavated between the superior keels, flattened and sloping sideways and downwards between the superior and superior laterals, ten keels present, superior lateral and median laterals sharply toothed; second segment also with ten keels, dorsal surface flattened into a broadly expanded plate between the two arched superior lateral keels which present a broadly toothed margin, superior keels indicated only by a row of tubercles, the median lateral, inferior lateral, and inferior median keels are smoothly represented in their anterior portion and become moulded posteriorly into large smooth tubercles; the third segment also shows slight

TEXT-FIG. 2.

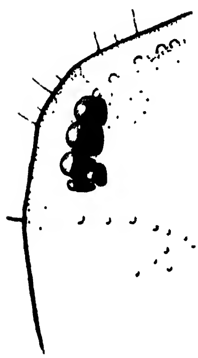


Apistobuthus pterygocercus, sp. n. Dorsal view of whole animal. ×2⅔.

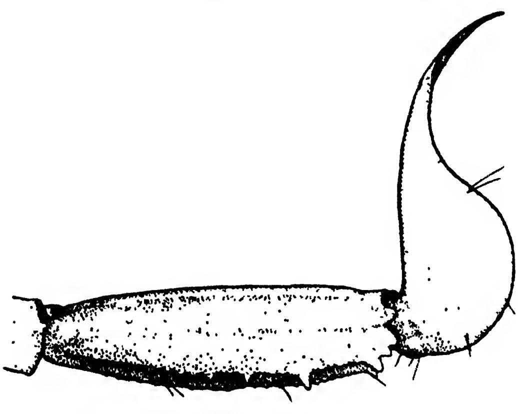
Text-fig. 4.



Text-fig. 3.



Text-fig. 5.



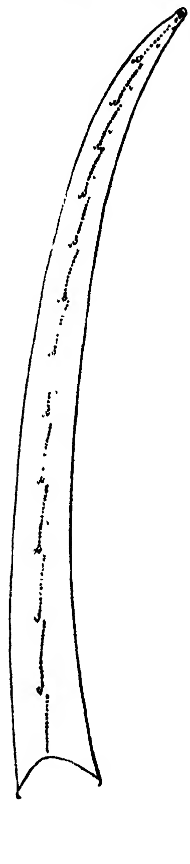
Apistobuthus pterygocercus, sp. n.

Fig. 3.—Lateral eyes of left side. ×12.
Fig. 4.—Ventral view of body. ×2⅔.
Fig. 5.—End of tail, from the side. ×6⅔.

depression, but has resumed a more normal shape, superior keels consist of four blunt tubercles, superior lateral of six or seven serrations on lateral margins of segment, median lateral keels absent, the four inferior keels strongly toothed; fourth segment narrower, less than half the width of the second segment, smooth and rounded dorsally, two stout apophyses on either side, just below articulation with preceding segment, superior lateral keel very faint, four

TEXT-FIG. 7.

TEXT-FIG. 6.



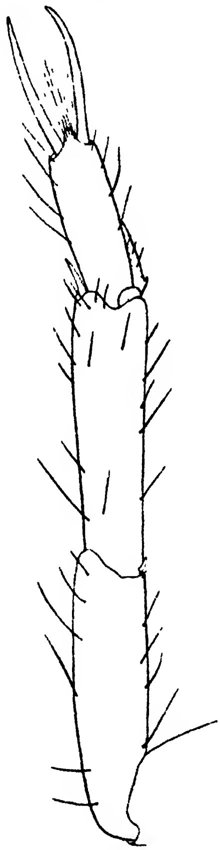
Apistobuthus pterygocercus, sp. n.

Fig. 6.—Mandible. ×20.
Fig. 7.—Finger. ×10.

inferior keels more marked bearing minute granules; fifth segment about the same width as fourth segment, smooth and rounded on dorsal surface, a row of small punctations lie in the position of the superior lateral keel, inferior lateral unevenly serrated, with several large teeth in the posterior half of the segment, lateral portion of posterior margin fluted. Vesicle without spine beneath aculeus, smooth, sparsely punctate, and furnished with fine hairs (text-fig. 5)

Immovable arm of *mandible* with two teeth on lower margin (text-fig. 6). Trochanter of *cheliped* with a crest of small tubercles on inferior surface and several short rows of granules on upper surface; humerus with three tuberculated keels. Brachium with only one keel definitely marked, outer keel indicated roughly by granules, inner margin toothed but not keeled. Hand short, smooth, and about one-fourth length of fingers, which are exceedingly long and slender. Thirteen rows of median teeth extend from tip to base

TEXT-FIG. 8.



Apistobuthus pterygocercus, sp. n. Fourth leg, showing tibial spur. × 11¼.

of fingers (text-fig. 7), last tooth of median series greatly enlarged; outer series consisting of a single row of teeth, situated just posteriorly and obliquely to the enlarged median tooth at the base of each of the ten distal median series; inner series also consisting of a single row of teeth, about the same size as those of the outer series, but smaller than the enlarged median tooth and situated about the level of the middle of the median series.

First three pairs of *legs* with the last three segments flattened below and protarsus somewhat flattened above, margins of tibia, protarsus and tarsus furnished with rows of long stiff setae, those of lower margin regular and stretching downwards, so that they are not seen in dorsal view; fourth pair of legs neither compressed nor armed with rows of setae. Tibial spurs absent on third pair of legs and present as a small weak spine on only one of the fourth pair of legs in two of the three specimens collected (text-fig. 8), absent from all the legs of the third specimen. Anterior pedal spur long, stout, and hairy, about one-third as long again as posterior spur. Claws nearly as long as tarsi, claw lobe well developed and hairy. *Pectines* long, teeth 36–56.

Measurements :—

	mm.
Total length	50·0
Length of cephalothorax	5·0
,, tail	32·0
Width at base of cephalothorax	6·0
,, anterior margin	3·5
Length to middle eye tubercle	2·5
Diameter of median eye	1·0
Length of median eye tubercle	1·5
Width of abdomen	6·5
,, anterior end of 6th abdominal segment	5·0
,, posterior end of 6th abdominal segment	2·5
Length of 6th abdominal segment	3·2
,, cheliped	31·5

Remarks.—The genus *Apistobuthus* is distinguished from all the other known genera of Buthids in the depression and expansion of the anterior segments of the tail and in the arching of the anterior portion of the cephalothorax from the ocular tubercle up to the higher level of the anterior margin. *Apistobuthus* is most nearly related to the genus *Plesiobuthus* described by Mr. Pocock in 1900 from Baluchistan ('The Fauna of British India, Arachnida,' p. 43, 1900). It differs from *Plesiobuthus* not only in the above points but also in the occurrence of tibial spines on the fourth pair of legs, and in the well-developed claw-lobes, and throws still further doubt on the wisdom of separating the Centurinae and Buthinae on the evidence of tibial spines.

Scientific results of the Cambridge Expedition to the East African Lakes, 1930–1.—1. General introduction and station list. By E. B. Worthington, M.A., Ph.D., Balfour Student at Cambridge University.

(Plates 1–5)

[Read 28 April 1932]

The Cambridge Expedition to the East African lakes was organised in 1930 to continue limnological investigations in Kenya and Uganda. The early African lake expeditions at the beginning of the century concentrated on Lake Tanganyika, but made collections of the fauna and flora of Lakes Victoria, Edward, Albert, etc., and other collections have been brought to European museums by individual collectors. A summary of knowledge up to date was given by Dr. Cunnington (1921), but since that time the sciences of limnology and ecology have undergone considerable development and we are now able to approach the problems from a somewhat different standpoint, considering the animals and plants in relation to their physical and biological environments, and attacking problems of geographic distribution with a sounder backing from geology. This modern type of research on the African lakes may be said to have started on Lake Victoria, the second largest lake in the world, with an area of 26,000 square miles, of which the biology was studied in detail by Mr. Michael Graham, whom I had the advantage of assisting, during the Government fishing survey in 1927–8. The results of this survey were embodied in an official report (Graham, 1929). Following on this a similar survey was made of Lakes Albert and Kioga in 1928, the results of which were published by Worthington (1929 etc.). In 1929 Miss Penelope Jenkin (1932) did detailed biological work on certain small lakes in the Kenya rift valley—Lakes Naivasha, Elmenteita, and Nakuru.

The object of last year's expedition was to complete the biological map of the Kenya and Uganda lakes. In Kenya, Lake Rudolf was the main objective, a vast area of water 185 miles long with a maximum width of 37 miles, only 1,250 feet above sea-level, which lies in the northern part of the Kenya rift valley and was very little known from the biological point of view. The deepest sounding we recorded was 73 metres (40 fathoms), but we have shown that the lake was formerly at a level 475 feet above the present, and therefore was three times as deep. When the lake was high during the pluvial periods it must have covered a vast area of what is now the Turkana desert, and we have concluded that it overflowed to the north-west into the basin of the Sobat river and so into the Nile near Khartoum. In those times the water must have been practically fresh, but in the period which intervened

between the pluvials and the present day the lowering of the lake-level has caused a concentration of dissolved salts until now the water is so alkaline as to be exceedingly unpleasant to drink (alkaline reserve = 0·02 Normal).

The daily shade temperature of the Lake Rudolf littoral reaches 100° or 110° F., and the vegetation map of Africa shows that the lake lies in an isolated area of desert or steppe-desert, the nearest similar vegetational areas being those of Somaliland and the Eritrean shore *. Consequently the land-fauna, which was collected in fair detail, is of considerable interest, as Mr. Parker's paper in this series on Reptiles will show. One of the best descriptions of this region yet published is that by von Höhnel (1894) concerning its original exploration.

Lake Baringo which was also studied in detail lies at a height of 3,150 feet in the rift valley to the south and is much smaller, about 12 by 6 miles. It is shallow with an even bottom at 7½ metres, and the water is yellow and muddy with a lower alkalinity (alkaline reserve = 0·006 Normal).

Continuing the series down the rift valley, Lakes Hannington, Nakuru, and Elmenteita are smaller very alkaline lakes (alkaline reserve = 0·16, 0·19, and 0·22 Normal respectively). The last two are very shallow, and Hannington is probably also shallow, though it has not been sounded in detail. Lake Naivasha lies at a height of 6,200 feet still further to the south in the rift valley; it measures about 8 by 9 miles and has a maximum depth of 18½ metres. Although, like the foregoing, it apparently lies in a closed drainage basin, the water is practically fresh (alkaline reserve = 0·003 Normal) and probably there is a subterranean outlet causing a through current of water. High-level beaches point to the conclusion that during the first (Kamasian) pluvial period all the Kenya rift lakes from Baringo to Magadi were united.

In Uganda, Lake Edward, the greater part of which lies within Belgian Congo Territory, and Lake George were the chief subjects of study. Lake Edward, which is 48 miles long by 25 miles wide, lies at a height of about 3,000 feet in the western rift valley. It was found to have a deep trough descending to a depth of 118 metres near the steep escarpment to the west, from which the bottom shelves evenly to the swampy south-east shore. On the other hand, Lake George, which is about 12 miles square and lies in a branch of the rift valley under Mt. Ruwenzori, is very shallow with an even bottom at 2½ metres; much of its shore is bordered by papyrus swamp. The two lakes are connected by the Kazinga Channel, a unique physiographical feature about 30 miles long by ½ mile wide, which presents bionomic problems of great interest. The region is beset with problems of river reversal and changes of lake-level, which have greatly affected the aquatic fauna.

* Unfortunately, several recently published maps (for instance, Hurst and Phillips, 1931) show the Rudolf region to have a high rainfall and to have a savannah or savannah-forest vegetation. This is probably due to lack of data concerning the area. Actually such information as there is suggests that the northern part of the Kenya rift in which Lake Rudolf lies has an annual rainfall considerably less than 20 inches, and the vegetation near the lake shore is certainly desert or scrub-desert except along the dry water-courses.

While the Expedition was in Uganda the Government took the opportunity of having surveys made of the following smaller lakes with a view to fisheries' development, which, of course, involved collecting the fauna and flora and studying the ecology :—

Lake Bunyoni is an excellent example of a modern lake with no indigenous fish-life, and lies at a height of 6,400 feet in the highland Kigezi district. It was formed in recent times by a lava flow which poured across one of the steep-sided Kigezi valleys, ponding a stream to form a beautiful fresh-water lake about 17½ miles long, some 40 metres deep, with long rambling bays and numerous islets.

Lakes Nakavali, Kachira, and Kijanebalola are an interesting series of shallow swampy waters lying on one of the drainage systems which virtually connect Lake Edward to Lake Victoria. They have a pronounced faunistic interest, since most of the modern fauna of Lake Edward was probably derived from Lake Victoria along these unique drainage systems, which arise in swamps and now flow both eastward to Lake Victoria and westward to Lakes Edward and George.

Lake Nabugabo is a small oval stretch of water 5 miles long by 3 miles wide and only 4½ metres deep, lying close to the north-west corner of Lake Victoria. It was originally a part of Victoria, but has become completely shut off by the growth of a sand-spit, and contains an isolated sample of the Victoria fauna. Along one side it is bordered by a large acid *Sphagnum* swamp, one of the very few acid swamps in East Africa. Nabugabo is less alkaline than any other East African lake.

A general account of the lake regions visited has already been published in the 'Geographical Journal' (Worthington, 1932), so it is unnecessary to burden this introduction with physiographical details. For further information concerning the smaller Kenya lakes, see Gregory (1921) and Leakey (1931).

The *personnel* consisted of Dr. E. B. Worthington as leader and zoologist, who concentrated on fish, plankton, the general ecology of the lakes, and fisheries' development. Mrs. Stella Worthington as geographer collaborated with the leader in all this work and in addition made detailed surveys and maps of parts of Lake Rudolf, the results of which are published here as Map 1. Mr. L. C. Beadle as chemist and zoologist was concerned with the study of water chemistry in relation to biology, and did other work on the bionomics of swamps to compare the conditions in Africa with those in the South American Chaco. Mr. V. E. Fuchs as geologist studied the high-level beaches and where possible made fossil collections representing the lake-faunas of the pluvial periods. Unfortunately, Fuchs was taken seriously ill with spirillum and malarial fevers after the first two months, and as a result was incapable of work for four months out of the year. After the other members returned to England, however, he joined Dr. L. S. B. Leakey's archaeological expedition in East Africa and spent an additional four months in the field continuing his researches. The other members of the expedition enjoyed good health on the whole, but Worthington and Beadle suffered from occasional

slight attacks of malaria and Mrs. Worthington was laid up for 10 days in camp on Lake Edward with dysentery.

For the first two months Mr. R. E. Dent, Assistant Game Warden in charge of fish in Kenya Colony, accompanied the expedition by arrangement with the Kenya Government. He collaborated in the biological work, his experience of the country was invaluable, and he saved the expedition a severe amount of expense and inconvenience by lending his house on the shore of Lake Naivasha for the whole year. This house was used as a headquarters, being in a healthy part of the country; not only was it an excellent place for recuperation after strenuous work in the unhealthy regions of Baringo and Rudolf, but it served as a base for investigations of Lake Naivasha itself. Mr. Dent's 20-foot sailing-boat on the lake was also lent to the expedition.

The *means of transport* to and from the lakes was always provided by motor-cars and lorries. Once arrived at the lake-shores travel was generally accomplished by open boat, but occasionally by foot safari and head-porterage. A 12 h.p. outboard motor was transported everywhere with the other equipment and attached to different craft as occasion demanded. It was chiefly due to the reliability of this machine that we were able to cover so much water, for small boat navigation on many of the lakes is difficult and sometimes dangerous by reason of the sudden storms and heavy swells.

The *itinerary* was as follows :—

The first two months in the company of Dent were occupied by a preliminary examination of the Kenya lakes. Work started at the beginning of November on Lake Naivasha, and at the end of November we moved to Baringo, transporting there a 14-foot open row-boat. In the middle of December we set out for Lake Rudolf and succeeded in transporting our equipment and a 20-foot metal lifeboat, lent to the expedition by the railway and harbour authorities and delivered by them to railhead at Kitale, over the 300 miles of bad road and desert from Kitale to the lake shore, arriving there on Christmas Eve 1930.

A fortnight was spent building a permanent base-camp at the mouth of the Kaliokwel River about half-way up the west shore of the lake, a situation partly protected by the sand-spit of Ferguson Bay. A preliminary visit was made to Central Island and a general idea gathered of the work waiting to be done. After returning to Naivasha for fresh supplies and equipment we moved to Baringo towards the end of January for the main working time on that lake. In the middle of March the expedition travelled again to Lake Rudolf for two months, during which Ferguson Bay, Central Island, and the adjoining parts of both east and west shores and the open water were studied in detail. During this time Beadle made a trek to the north end of the lake near Lokitaung, while the Worthingtons accomplished a long open-boat journey, crossing the lake in two places and examining unknown parts of its shores.

During May some further work was done on Lake Naivasha and the whole expedition moved its headquarters from Naivasha to Lake Edward in Uganda,

taking a 16-foot open boat specially designed for the outboard motor and built from timber obtained locally, the first non-native craft on either Lakes Edward or George. Work started at Katunguru on the Kazinga Channel at the end of May, continued on Lake Edward through June and July, during which time the Worthingtons made a boat journey round and across the lake, while Beadle and Fuchs, working from the land, studied the shores and walked into the Congo to visit the Semliki Falls and nearby regions. Most of July and the beginning of August was spent on Lake George, after which Beadle had to return to England and Fuchs to Naivasha. Dr. and Mrs. Worthington then moved to Lake Bunyoni for a clear fortnight and afterwards spent another month until the middle of September examining Lakes Nakavali, Kachira, Kijanebalola, and Nabugabo. They returned to England at the end of October after submitting preliminary reports to the Uganda Government.

The whole expedition cost the sum of about £1,700, which was contributed by the following bodies :—Royal Society Government Grants, British Museum (Nat. Hist.), Percy Sladen Memorial Trust, British Association, Cambridge Balfour Fund, Royal Geographical Society, Gloyne Fund, Gonville and Caius College, Worts Fund, and the Uganda Government. In submitting the accounts a balance of £170 was shown, which it has been arranged to put towards the expense of publishing the scientific results in the 'Journal of the Linnean Society.'

The collections have been sorted at the Zoological Laboratory, Cambridge, and at the Natural History Museum, South Kensington, where all the specimens will be deposited finally. The different groups of organisms have been submitted to the following authorities for examination, several of whom will be contributing papers in the series of results :—

Mammals to Miss St. Leger ; Reptiles and Amphibians to Mr. H. W. Parker ; Cichlid fishes to Dr. C. Tate Regan, F.R.S., and Miss E. Trewavas ; fishes other than Cichlidae to Dr. E. B. Worthington ; Mollusca to Major M. Connolly ; Oligochaeta to Lt.-Col. J. Stephenson, F.R.S. ; Parasitic Worms to Dr. H. A. Baylis ; Leeches to Dr. J. Percy Moore ; Sponges to Mr. M. Burton ; Polyzoa to Dr. A. Hastings ; Rotifera to Prof. P. de Beauchamp ; large Crustacea to Dr. I. Gordon ; Argulidae to Dr. W. A Cunnington ; parasitic Copepoda to Mr. Leigh-Sharpe ; Planktonic Crustacea to Mr. A. G. Lowndes ; Myriapoda and Arachnida to Dr. S. Finnegan ; Hydrachnida to Dr. O. Lundblad ; adult insects to members of the British Museum entomological department ; insect larvae to Dr. A. D. Imms ; land-plants and water-weeds to Mr. J. Ramsbottom ; and Phytoplankton to Miss F. Rich.

As a result of the expedition's work it may now be said that all the important lakes in Kenya and Uganda have received a thorough preliminary biological survey, but it is not claimed that every organism from every lake has been collected ; such a feat would have been impossible with the time at our disposal, and indeed certain forms of life are inevitably overlooked in any faunistic work. Many problems have been cleared up, but at the same time many others have been opened for further investigations. Moreover, there

are still many fresh waters in this region not yet studied at all. The rivers and streams present innumerable problems in themselves, and it has not yet been possible to examine the small crater lakes which abound in the Ankole and Toro districts of Uganda. In Kenya, Lake Magadi, a saturated solution of soda with fresh-water streams flowing into it, and Lake Jipe, which lies under the massive volcano of Kilimanjaro, have been left out of our work. In Tanganyika Territory there are still untouched fields for fresh-water research: the large alkaline lakes of Natron and Eyassi in the eastern rift have not yet even been collected and the abyssal depths of Lake Tanganyika itself, which is known to be almost a mile deep, have only been plumbed at three points, while nothing is known of the abyssal fauna which may or may not live near the bottom. Lake Nyassa presents similar deep-water problems which could not be tackled by the early expeditions owing to lack of suitable equipment. It is to be hoped, therefore, that before long a further expedition will be organized, thoroughly equipped for deep-water work, to proceed to Tanganyika, Nyassa, and the small unknown lakes of Tanganyika Territory with the object of elucidating still further the problems of the African lakes.

I should like to take this opportunity of thanking the members of the expedition for their helpfulness, often in trying conditions, Professor J. Stanley Gardiner for assistance in organizing the expedition before leaving England and for advice in all its stages, His Excellency Sir William Gowers for his interest and help in Uganda, and the many friends both in East Africa and in England who have helped the expedition on its way.

The following Station List is abridged from the expedition's log-books, to include only those stations from which specimens were preserved. The object of printing it here is to save much unnecessary space in the following series of papers, since the locality and data concerning specimens can be referred to simply by a station number.

Maps 1–3 are reproduced from the 'Geographical Journal,' vol. lxxix, by permission of the Royal Geographical Society. Maps 4 and 5 have been prepared by my wife.

References.

Cunnington, W. A. 1920. Fauna of the African Lakes. Proc. Zool. Soc. London, 1920, pp. 507–622.

Graham, M. 1929. Victoria Nyanza and its Fisheries. (Crown Agents for the Colonies.)

Gregory, J. W. 1921. Rift Valley and Geology of East Africa. (Seeley, Service and Co.)

Höhnel, L. von. 1894. Discovery of Lakes Rudolf and Stefanie. (Longmans, Green & Co.)

Hurst H. E., & Phillips, P. 1931. The Nile Basin, vol. i, Phys. Dept. Paper no. 26. Govt. Press, Cairo.

Jenkin, P. M. 1932. Reports on the Percy Sladen Expedition to some Rift Valley Lakes in Kenya in 1929.—I. Introductory Account . . . . . Ann. & Mag. Nat. Hist. ser. 10, ix, pp. 533–553.

Leakey, L. S. B. 1931. East African Lakes. Geogr. Journ. lxxvii, pp. 497–514.

Worthington, E. B. 1929. Report on the Fishing Survey of Lakes Albert and Kioga. (Crown Agents for the Colonies.)

——. 1932. The Lakes of Kenya and Uganda. Geogr. Journ. lxxix, pp. 275–97.

ABRIDGED STATION LIST.

Lake Naivasha.

Station.	Date.	Time.	Locality.	Gear.	Notes.
1......	10/11/30.	1800–0630.	E. shore.	gill-nets.	depth 3 m.
2......	11/11/30.	0630–1600.	,,	,,	,,
3......	12/11/30.	1200–1400.	E. shore off McRae's.	,,	,,
5......	13/11/30.	1700–1200.	mid-lake.	,,	depth 7 m.
6......	,,	1210–1220.	,,	dredge, plankton-nets.	horizontal haul.
7......	15/11/30.	0700.	E. shore.	—	native fishing.
8 & 9..	,,	1230.	,,	pond-net &c.	weedy shore-collection.
10 A ...	16/11/30.	—	pond on Kinankop.	—	,,
11......	17/11/30.	1100.	weed area of E. shore.	winch, pond-net, &c.	general collection.
12......	19/11/30.	1700–0700.	E. shore.	gill-nets.	—
14......	20/11/30.	1630–1700.	Crescent Is. crater.	water-bottle, plankton-nets.	depth 17 m., vertical hauls.
15......	,,	1750–0700.	E. shore.	gill-nets.	—
16......	21/11/30.	1400.	rainpool.	pond-net.	collection.
18......	23/11/30	1300.	middle of lake.	plankton-nets, water-bottles.	depth 10 m., vertical hauls. dhan-buoy fixed
19......	,,	1500.	Crescent Is. crater.	water-bottle.	depth 18 m., dhan-buoy fixed.
21......	24/11/30.	0830.	,,	,,	—
22......	25/11/30.	0830–0630.	,,	gill-nets.	—
23......	,,	1200.	Morendat River.	pond-net.	shore-collection.
24......	26/11/30.	1300–1700.	W. of lake near rocky islets.	gill-nets.	—
26......	9/2/31.	1800–0600.	near E. shore.	,,	—
27......	24/2/31.	—	E. shore.	pond-net &c.	fishermen's collecting.
28......	,,	1100.	near E. shore.	plankton-nets.	horizontal hauls.
29......	26/2/31.	1230 onwards.	Crescent Is. crater.	coarse plankton-net.	24 hours' plankton observations, vertical hauls.
30......	,,	,,	,,	fine plankton-net.	—
31......	27/2/31.	1700.	weed area near E. shore.	plankton-nets.	vertical hauls.
32......	28/2/31.	—	L. Nakuru.	pond-net &c.	shore-collection.
33......	1/3/31.	1100–1600.	crater lake 2 miles W. of L. Naivasha.	plankton-nets, grabs, water-bottles, &c.	vertical hauls.

Lake Naivasha (continued).

Station.	Date.	Time.	Locality.	Gear.	Notes.
34......	1/3/31.	1100–1600.	crater lake 2 miles W. of L. Naivasha.	pond-net.	muddy shore-collection.
35......	2/3/31.	1600.	Crescent Is. crater.	centrifuge, water-bottle.	centrifuge plankton.
36......	3/3/31.	1500.	,,	,,	,,
37......	5/3/31.	1700–0630.	near E. shore.	gill-nets.	—
38......	8/3/31.	1200.	S.W. bay of Naivasha.	plankton-nets.	depth 11·7 m., vertical hauls.
38 A ...	,,	,,	,,	water-bottle, centrifuge.	lines of sounding made.
39......	,,	—	E. shore.	pond-net &c.	shore-collecting.
40......	11/3/31.	1200.	near centre of lake.	plankton-nets.	depth 7 m., vertical hauls.
42......	11/5/31.	1200.	Crescent Is. crater.	,,	depth 8 m., vertical hauls.
43......	,,	1230.	weedy area near E. shore.	,,	depth 3 m., vertical hauls.

Lake Baringo.

Station.	Date.	Time.	Locality.	Gear.	Notes.
101.....	4/12/30.	1100	S.W. shore.	seine &c.	sandy shore collection.
102.....	5/12/30.	0630–1700.	near S.W. shore.	gill-nets.	depth 4 m.
103.....	,,	1730–1130.	,,	long line.	small hooks.
104.....	,,	1100.	,,	pond-net &c.	sandy shore collection.
103 A ..	6/12/30.	1800–1000.	,,	long line.	large hooks.
105.....	7/12/30.	1100–0630.	near rocky island.	gill-nets.	depth 7 m.
105 A ..	,,	1130–1300.	,,	thermometers, &c.	lines of soundings.
106 B ..	,,	1700.	S.W. shore.	seine.	—
106.....	8/12/30.	1200.	near rocky. island.	plankton-nets.	depth 7 m.
106 A ..	9/12/30.	—	S. shore.	pond-net &c.	swamp-collection.
107.....	,,	—	open water.	grab.	lines of soundings.
108.....	,,	1600–0600.	,,	gill-nets, long line.	—
109.....	,,	1100.	S.W. shore.	—	sandy shore collection.

Lake Baringo (continued).

Station.	Date.	Time.	Locality.	Gear.	Notes.
111.....	24/1/31.	1100.	river at Marigat.	seine &c.	stony shore collection.
112.....	25/1/31.	1100.	S.W. shore.	pond-net &c., plankton-nets.	,,
114.....	26/1/31.	0900–1200.	S. shore.	pond-net &c.	swamp-collection.
115.....	,,	1600–1700.	W. shore.	—	stony shore collection.
116.....	27/1/31.	1800–0600.	open water near rocky island.	gill-nets.	dhan-buoy fixed.
117.....	28/1/31.	0900.	,,	plankton-nets.	horizontal hauls.
118.....	,,	1700–0600.	,,	gill-nets.	depth 7 m.
119.....	,,	,,	,,	long line.	—
119 A ..	28/1/31.	1100–1130.	open water near rocky island.	trawl.	—
121.....	,,	1700.	,,	grab, plankton-nets, dredge.	depth 7 m., vertical hauls.
122.....	30/1/31.	1700–1800.	,,	trawl.	3 hauls.
123.....	31/1/31.	0600.	,,	water-bottle centrifuge.	—
124.....	,,	1000.	,,	plankton-nets.	vertical hauls.
125.....	,,	1200.	,,	centrifuge.	—
126.....	,,	1600.	,,	native fishing.	lines of soundings.
127.....	,,	1700–1800.	rocky island.	pond-net &c.	shore-collection.
128.....	2/2/31.	1100.	large island.	—	hot-spring collection.

Lake Hannington.

Station.	Date.	Time.	Locality.	Gear.	Notes.
129.....	3/2/31.	—	N. shore.	pond-net &c.	muddy shore collection.
130.....	,,	—	river entering lake.	,,	,,
131.....	4/2/31.	—	N. shore.	seine.	—
132.....	,,	—	river entering lake.	pond-net.	shore-collection.
134.....	,,	—	N.E. shore.	pond-net.	,,

Lake Rudolf.

Station.	Date.	Time.	Locality.	Gear.	Notes.
201.....	24/12/30.	0630.	base camp at mouth of Kalıokwel River.	seine.	muddy shore.
202.....	”	1100.	lee of Ferguson spit.	”	sandy shore.
204.....	”	1800–0600.	Ferguson Bay.	gill-nets.	depth 3 m.
205.....	Xmas Day.	1500.	lee of Ferguson spit.	seine.	sandy shore.
206.....	26/12/30.	0600.	base camp.	—	native fishermen with catch.
207.....	”	1100–1530.	Ferguson Bay.	gill-nets.	depth 4 m.
207 A ..	”	1130–1600.	lee of Ferguson spit.	2″ gill-net.	along shore.
208 A ..	”	1300.	”	long line for *Lates*.	—
209.....	”	1500.	”	seine.	sandy shore.
210.....	29/12/30.	0600.	base camp.	—	native fishermen's catch.
211.....	”	1000–1400.	just outside Ferguson Bay.	gill-nets.	—
211 A ..	”	1030.	Ferguson spit.	long line for *Lates*.	—
211 B ..	”	1130.	”	pond-net &c.	collection in closed alkaline pool.
212.....	30/12/30.	0600.	base camp.	—	native fishermen.
213.....	”	1230.	”	pond-net &c.	shore-collection.
214.....	31/12/30.	0600.	”	—	native fishermen.
215.....	1/1/31.	1045-0630.	open water 1 mile from spit.	gill-nets.	bottom fishing, depth 18·5 m.
216.....	”	1200.	”	plankton-nets.	depth 18·5 m., vertical hauls.
217.....	2/1/31.	1200–1700.	Ferguson Bay.	gill-nets.	depth 3 m., crocodile smashed nets.
218.....	3/1/31.	1200.	Central Island.	pond-net.	shore-collection, lines of soundings.
219.....	4/1/31.	1800.	lee of Ferguson spit.	seine.	sandy shore, 3 hauls.
220.....	5/1/31.	0900-1100.	base camp.	pond-net and sieves.	shore-collections.
221.....	6/1/31.	1600–1800.	lee of Ferguson spit.	2″ gill-net.	set along weedy shore.
221 A ..	”	”	off point of Ferguson spit.	”	—
222.....	”	1700.	”	seine.	—
223.....	”	1830.	”	long line.	—

Lake Rudolf (continued).

Station.	Date.	Time.	Locality.	Gear.	Notes.
225.....	7/1/31.	1800–1400.	lee of Ferguson spit.	long line.	—
226.....	8/1/31.	0730–1130.	open water near Central Island.	gill-nets.	depth 60 m., bottom fishing, lines of sounding.
227.....	,,	0800.	,,	grab.	depth 57 m.
228.....	9/1/31.	1700.	lee of Ferguson spit.	seine.	4 hauls.
229.....	10/1/31.	1700–1900.	,,	gill-nets.	—
230.....	,,	1730–1900.	,,	Long line.	—
231.....	20/3/31.	1100.	,,	1" seine.	—
232.....	,,	1100–1500.	,,	long line.	—
232 A ..	,,	1200.	off point of spit.	trawl.	much mud.
234.....	21/3/31.	1100.	open water 1 mile off spit.	plankton-nets.	depth 25 m., vertical hauls.
235.....	,,	,,	rain-pools near base camp.	pond-net.	pool collection.
236.....	22/3/31.	1500–1100.	open water beyond spit.	gill-nets.	depth 12 m., surface fishing, dhan-buoy fixed.
237.....	,,	0900.	lee of Ferguson spit.	long line.	Record *Lates*, 95 kg.
238.....	24/3/31.	1100.	,,	1" seine.	—
240.....	,,	1700.	base camp.	pond-net.	collection from enclosed river-mouth.
241.....	24/3/31.	1800.	base camp.	—	shore shell collection.
242.....	,,	1730.	Ferguson spit.	seine.	crocodile smashed seine.
243.....	,,	1800.	,,	long line.	—
244.....	25/3/31.	1600.	Ferguson Bay.	seine.	—
245.....	27/3/31.	1100.	,,	,,	—
246.....	,,	1130.	,,	pond-net.	sandy shore collection.
247.....	28/3/31.	0900.	S. end of Ferguson Bay.	plankton-nets.	depth 3 m., horizontal haul.
248.....	,,	1000.	intermediate position.	,,	depth 4 m., horizontal haul.
249.....	,,	1100.	,,	,,	depth 3·3 m., horizontal hauls.
250.....	,,	1200.	N. end of Ferguson Bay.	,,	depth 4·7 m., horizontal hauls.
251.....	,,	—	S. end of Ferguson Bay.	pond-net.	shore-collection.

Lake Rudolf (continued).

Station.	Date.	Time.	Locality.	Gear.	Notes.
253.....	30/3/31.	0900.	lee of spit.	seine.	—
254.....	,,	0930–1800.	,,	long line.	—
255.....	,,	1000–1215.	Ferguson Bay.	gill-nets.	—
257.....	,,	1300.	Ferguson spit.	—	algae from closed alkaline pool.
258.....	31/3/31.	0900.	entrance to Ferguson Bay.	plankton-nets.	depth 9·1 m., horizontal hauls.
259.....	,,	1000.	intermediate position.	,,	depth 12 m., horizontal hauls.
260.....	,,	1100.	open water.	,,	depth 17 m., horizontal hauls.
261.....	,,	1200.	,,	,,	depth 21 m., horizontal hauls.
262.....	,,	1230.	outside of spit.	gun.	pelican and cormorant stomachs.
263.....	2/4/31.	1800 onwards.	open water W. of Central Is.	plankton-nets.	depth 48 m., 24 hours' plankton observations, vertical hauls.
264.....	,,	1700.	Central island.	1″ seine.	—
266.....	,,	1700.	,,	gun.	fishes shot.
267.....	3/4/31.	0900–1700.	open water.	gill-nets.	depth 50 m., bottom fishing.
269.....	,,	1000.	crater lake B.	—	plankton-collection.
270.....	4/4/31.	1000.	crater lake A.	1″ seine.	—
271.....	,,	1100.	,,	plankton-nets.	depth 9 m., horizontal hauls.
273.....	,,	1600.	crater lake C.	1″ seine.	water sample preserved.
274.....	5/4/31.	—	Central Island.	—	shore shell collections.
275.....	8/4/31.	1700.	Ferguson Bay.	trawl.	3–4 m.
277.....	9/4/31.	1700.	,,	gill-nets.	—
278.....	11/4/31.	—	S. end Ferguson Bay.	1″ seine.	—
280.....	,,	—	base camp.	pond-net.	alkaline pool collection.
281.....	12/4/31.	—	Central Island.	,,	rocky shore collection.
283.....	14/4/31.	0900.	E. shore of lake near Mt. El Moitat.	,,	sandy shore collection.
284.....	,,	0600.	,,	—	fossil shell collection.

Lake Rudolf (continued).

Station.	Date.	Time.	Locality.	Gear.	Notes.
285.....	14/4/31.	1100.	E. shore near Mt. El Moitat.	1″ seine and pond-net.	weedy lagoon.
286.....	15/4/31.	0630.	,,	pond-net.	weedy shore.
287.....	,,	,,	,,	1″ seine.	,,
288.....	15/4/31.	0900–1200.	,,	gill-nets.	depth 2 m.
289.....	,,	—	,,	1″ seine.	muddy shore, baby crocodiles.
290.....	,,	—	,,	pond-net.	shore collection.
291.....	16/4/31.	1200.	near Turkwel River mouth, W. of lake.	,,	hot fresh-water spring.
292.....	17/4/31.	—	,,	—	shore shells.
293.....	,,	—	Adach lagoon.	1″ seine, pond-net.	muddy shore.
295.....	19/4/31.	1700–0900.	Ferguson Bay.	long line.	—
296.....	17/4/31.	1700–0800.	N.W. shore, near Mt. Labur,	gill-nets.	—
298.....	21/4/31.	0630.	open water ½ mile beyond spit.	plankton-nets, grab, centri-fuge.	depth 19·8, vertical hauls.
299.....	,,	1800–0630.	,,	gill-nets.	—
301.....	22/4/31.	—	base camp.	pond-net, 1″ seine.	muddy shore.

Kazinga Channel.

Station.	Date.	Time.	Locality.	Gear.	Notes.
501.....	24/5/31.	1700–0630.	Katunguru, mid-channel.	gill-nets.	depth 2·5 m.
502.....	,,	,,	,,	long line.	small hooks.
503.....	25/5/31.	—	,,	—	native fisher-men's catch.
504.....	,,	1700–0600.	,,	gill-nets.	close to papyrus edge.
505.....	26/5/31.	1700–0630.	1 mile N.E. of Katunguru.	gill-nets.	depth 2·5 m.
506.....	27/5/31.	1700–0630.	Katunguru.	gill-nets.	set very close to shore.
507.....	28/5/31.	1100.	,,	pond-net.	collection from papyrus swamp.
508.....	,,	1400.	,,	1″ seine.	—
509.....	,,	1700–0600.	,,	long line.	—

Kazinga Channel (continued).

Station.	Date.	Time.	Locality.	Gear.	Notes.
510.....	29/5/31.	1100.	Katunguru.	plankton-nets.	horizontal hauls.
511.....	,,	1200.	,,	1″ seine, pond-net.	shore collection.
512.....	30/5/31.	—	River Chambura near Katunguru.	1″ seine, pond-net.	,,
513.....	,,	1700–0600.	2 miles N.E. of Katunguru.	gill-nets.	lines of soundings.
514.....	31/5/31.	,,	W. of Katunguru.	,,	depth 2·5 m.
516.....	2/6/31.	—	near Katunguru.	pond-net.	collection from papyrus swamp.
516 A ..	,,	—	Katunguru.	,,	weed collection.

Lake Edward.

Station.	Date.	Time.	Locality.	Gear.	Notes.
517.....	5/6/31.	1700–0800.	1½ miles beyond mouth of Kazinga Channel.	gill-nets.	depth 2·5 m.
518.....	,,	1800–0600.	mouth of Channel.	long line.	—
519.....	6/6/31.	,,	as 517.	gill-nets.	—
520.....	8/6/31.	—	Mweya promontory.	1″ seine, pond-net.	—
521.....	,,	—	mouth of Channel.	—	—
522... {	9/6/31. 11/6/31.	} —	rivers along East shore.	pond-net.	Invertebrate collections.
523.....	8/6/31.	1700–0700.	3 miles W. of Channel mouth.	gill-nets.	depth 8·3 m.
524.....	9/6/31.	1100.	5 miles S. of Channel mouth.	large and small seines.	—
525.....	,,	1700–0600	As 518.	long line.	—
527.....	11/6/31.	1000.	½ mile up Channel.	plankton-nets.	horizontal hauls.
528.....	,,	1030.	½ mile } W. of Channel mouth.	,,	,,
529.....	,,	1100.	1 mile } W. of Channel mouth.	,,	,,
530.....	,,	1130.	2 miles } W. of Channel mouth.	,,	,,

Lake Edward (continued).

Station.	Date.	Time.	Locality.	Gear.	Notes.
531.....	11/6/31.	1700–0630.	2½ miles N.W. of Channel mouth.	gill-nets.	depth 4 m.
532.....	12/6/31.	1700–0630.	¼ mile up Channel.	,,	—
534.....	15/6/31.	—	Katwe.	1″ seine.	—
535.....	,,	1700–0600.	near Katwe.	long line.	—
536.....	,,	,,	,,	gill-nets.	—
537.....	17/6/31.	—	near Kisenyi, E. shore.	grab.	depth 7·1 m., lines of soundings.
538.....	,,	1800–0600.	,,	gill-nets.	depth 8·5 m.
539.....	18/6/31.	1600–0600.	,,	long line.	,,
540.....	19/6/31.	0700.	,,	seine.	—
541.....	19/6/31.	0900.	,,	—	shore shell collection.
542.....	,,	1100.	mouth of R. Niamweru.	1″ seine, pond-net.	shore collection.
543.....	,,	1300.	1 mile S. of 542.	,,	,,
544.....	,,	1700–0600.	near Kanyamwongo.	gill-nets.	depth 8·8 m.
544 A ..	,,	1700.	,,	grab.	depth 8·8 m., lines of soundings.
545.....	20/6/31.	0900.	,,	seine.	—
546.....	,,	1100.	,,	plankton-nets.	depth 11·8 m., vertical hauls.
547.....	,,	1200.	open water behind K. spit.	pond-net.	depth 1·2 m.
548.....	,,	1700–0600.	near Kanyamwongo.	gill-nets.	depth 4·6 m.
549.....	21/6/31.	1200.	mouth of R. Ishasha.	seine.	International boundary.
551.....	,,	1700–0530.	near Katanda.	gill-nets.	depth 6 m.
552.....	22/6/31.	1200.	open water, 5 miles from W. shore.	plankton-nets, grab, pond-net, water-bottle.	depth 60·2 m., vertical hauls, line of soundings on crossing lake.
554.....	,,	1700–0630.	¼ mile from W. shore.	gill-nets.	depth 55·4 m., bottom fishing.
555.....	23/6/31.	0900–1800.	close to shore.	2″ gill-net.	depth 2 m.
556.....	,,	1000.	¼ mile from shore.	plankton-nets.	depth 58·9 m., vertical hauls.
557.....	,,	1500.	W. shore.	pond-net &c.	rocky shore collection.

Lake Edward (continued).

Station.	Date.	Time.	Locality.	Gear.	Notes.
558.....	24/6/31.	1700–0530.	Congo shore.	gill-nets.	depth 13 m., bottom fishing.
559.....	25/6/31.	1400.	1½ miles from Congo shore, further N.	water-bottle &c.	depth 117 m.
560.....	26/6/31.	—	2 miles from Congo shore, further N.	,,	depth 93·5 m.
561.....	,,	1200.	,,	gun.	pelican stomachs.
563.....	26/6/31.	1700.	Semliki source.	rod.	18 fish,
564.....	27/6/31.	1700–0630.	near Semliki source.	gill-nets.	depth 3·5 m.
565.....	28/6/31.	1100.	,,	1″ seine.	—
566.....	,,	—	,,	—	collection of shore and fossil shells.
567.....	29/6/31.	1200.	Semliki River.	1″ seine, pond-net.	shore collection.
568.....	,,	1700.	,,	gun.	cormorant stomachs.
569.....	,,	1800–0630.	near Kasomia.	gill-nets.	depth 7 m.
570.....	30/6/31.	1100.	,,	pond-net.	stony shore collection.
570 A ..	2/7/31.	1200–0600.	¾ mile W. of Kazinga Channel mouth.	gill-nets.	—
571.....	3/7/31.	1200.	near middle of lake.	plankton-nets, water-bottle &c.	depth 33·7 m., vertical hauls, lines of soundings.
572.....	5/7/31.	1300.	near Kisenyi, E. shore.	seine.	—
573.....	,,	1500.	near Kisenyi.	pond-net.	swamp-collection.
574.....	12/7/31.	1200.	deep open water.	plankton-nets, water-bottle, &c.	depth 90 m. vertical hauls.
575.....	,,	1800.	source of Semliki.	—	shore collection.
576.....	13/7/31.	—	Kaianda lagoon.	plankton-nets.	horizontal hauls.

Lake George.

Station.	Date.	Time.	Locality.	Gear.	Notes.
600.....	15/7/31.	1100.	E. end of Kazinga Channel.	gill-nets.	depth 3·5 m.
600 A ..	,,	,,	,,	long line.	—
601.....	15/7/31.	—	E. end of Kazinga Channel.	seine.	sandy shore.
602.....	16/7/31.	1000.	,,	plankton-nets.	horizontal ½ min. hauls at surface.
603.....	,,	—	,,	pond-net.	rain-pools behind camp.
604.....	19/7/31.	1730–0600.	,,	gill-nets.	depth 3·5 m.
605.....	18/7/31.	—	crater-lakes Bagusa and Masecha.	pond-net &c.	—
606.....	21/7/31.	—	E. end Kazinga Channel.	pond-net.	stones and rocks.
607.....	,,	1700–0600.	,,	gill-nets.	depth 3·0 m.
608.....	23/7/31.	1700–0600.	L. George near Channel.	gill-nets.	—
609.....	24/7/31.	—	E. shore of lake.	—	shore-collection.
610.....	,,	1800–0600.	½ mile down Channel.	gill-nets.	—
611.....	,,	1830–0630.	E. end of Channel.	long line.	—
612.....	26/7/31.	1800–0600.	Mayura.	gill-nets.	depth 2·5 m., ¾ mile out.
613.....	27/7/31.	—	,,	seine.	sandy shore.
614.....	,,	1800–0630.	,,	gill-nets.	depth 2·2 m., 1¼ miles out.
615.....	28/7/31.	—	cruising up E. shore.	pond-nets.	floating Nile cabbage.
616.....	,,	—	,,	rifle.	pelican stomachs.
617.....	,,	—	N. shore, in river mouth.	pond-net, plankton-net.	swamp collection.
618.....	29/7/31.	—	N.E. corner of lake.	seine.	mud shore.
619.....	,,	1800–0600.	,,	gill-nets.	near papyrus swamp.
620.....	29/7/31.	1800–0600.	N.E. corner of lake.	2″ net.	tied to papyrus.
622.....	30/7/31.	1100.	near N. shore.	plankton-nets.	brown water near papyrus swamp.
623.....	,,	1130.	,,	,,	green water, depth 2·8 m.
624.....	,,	1700–0600.	Iragara Isl.	gill-nets.	—
625.....	,,	,,	,,	long line.	—

Lake George (continued).

Station.	Date.	Time.	Locality.	Gear.	Notes.
626.....	31/7/31.	1100.	Iragara Isl.	pond-net.	rain-pools behind shore.
627.....	,,	—	,,	—	native fishermen.
628.....	1/8/31.	—	,,	pond-net.	muddy shore.
628 A & B	2/8/31.	1800–0600.	E. end of Kazinga Chan.	long line.	—
629.....	,,	1215.	Kisenyi.	seine.	sandy shore.
630.....	3/8/31.	0930–1200.	,,	gill-nets.	—

Lake Bunyoni.

Station.	Date.	Time.	Locality.	Gear.	Notes.
702.....	12/8/31.	overnight.	all round shores.	—	native fishermen with baskets.
703.....	13/8/31.	,,	near Bufundi.	—	,,
703 A ..	,,	,,	Bufundi.	—	,,
704.....	12/8/31.	—	,,	gill-nets.	close to weeds.
705.....	,,	—	,,	pond-net.	at landing.
705 A ..	13/8/31.	1130.	,,	grab.	depth 39·2 m., dhan-buoy fixed in middle of lake.
707.....	,,	—	,,	pond-net.	near shore in weeds.
709.....	,,	1500.	,,	plankton-nets.	depth 37 m., vertical hauls.
711.....	14/8/31.	—	southerly arm of lake.	pond-net.	depth 3·8 m., among weeds.
713.....	,,	—	near Bufundi.	gun.	otter stomachs.
714.....	15/8/31.	—	Eastern arm.	gun.	cormorant stomach.
715.....	16/8/31.	—	Bufundi.	pond-net.	in water-lilies.
716.....	,,	—	,,	,,	depth 10 m., in weeds.
720.....	,,	—	,,	pond-net.	swamp collection.
721.....	18/8/31.	—	Western arm of lake.	,,	middle of deep part of lake.
722.....	,,	1400.	,,	plankton-nets.	depth 29·5 m., oblique hauls.
723.....	19/8/31.	—	Bufundi.	grab.	depth 16·5 m., mud.
723 A ..	,,	—	,,	pond-net.	along shore.
724.....	,,	—	,,	,,	among lilies.

Lake Bunyoni (continued).

Station.	Date.	Time.	Locality.	Gear.	Notes.
729.....	19/8/31.	1700–0700.	Bufundi.	gill-nets.	among weeds.
730.....	20/8/31.	2200.	,,	plankton-nets.	depth 37 m., vertical hauls at buoy.
731.....	22/8/31.	1700–0700.	,,	gill-nets.	close to lilies by island opposite camp.

Lake Nakavali.

Station.	Date.	Time.	Locality.	Gear.	Notes.
801.....	28/8/31.	1700–0630.	middle of lake.	gill-nets.	—
802.....	,,	1100.	S. end of lake.	seine.	by landing.
803.....	,,	1200.	,,	pond-net.	,,
804.....	,,	1800.	,,	baskets.	native fishermen.
806.....	29/8/31.	overnight.	,,	,,	,,
807.....	,,	,,	,,	long lines.	,,
809.....	31/8/31.	1100–1000.	N. end of lake.	,,	—
811.....	,,	1000–1700.	S. bay.	2″ gill-net.	by water-lilies in bay.
812.....	,,	—	,,	pond-net.	among weeds.
813.....	1/9/31.	—	S. end of lake.	collecting.	lumps of papyrus on shore.
814.....	,,	—	middle of lake.	plankton-nets.	horizontal hauls.
815.....	,,	—	,,	gun.	darter stomachs.
816.....	,,	0600–1700.	S. bay.	2″ gill-net.	—

Lake Kachira.

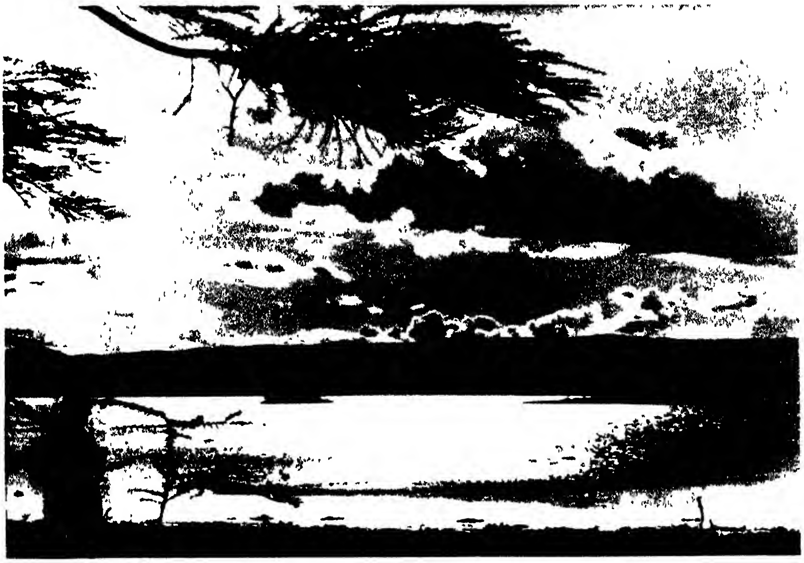
Station.	Date.	Time.	Locality.	Gear.	Notes.
822.....	4/9/31.	—	W. shore.	long line.	native fishermen.
823.....	,,	—	,,	baskets.	,,
824.....	,,	—	middle of lake.	plankton-nets.	depth 4·0 m., horizontal hauls.
826.....	,,	—	W. shore.	seine.	in 2 muddy clearings.
827.....	,,	—	E. shore.	pond-net.	among weeds.

Lake Kijanebalola.

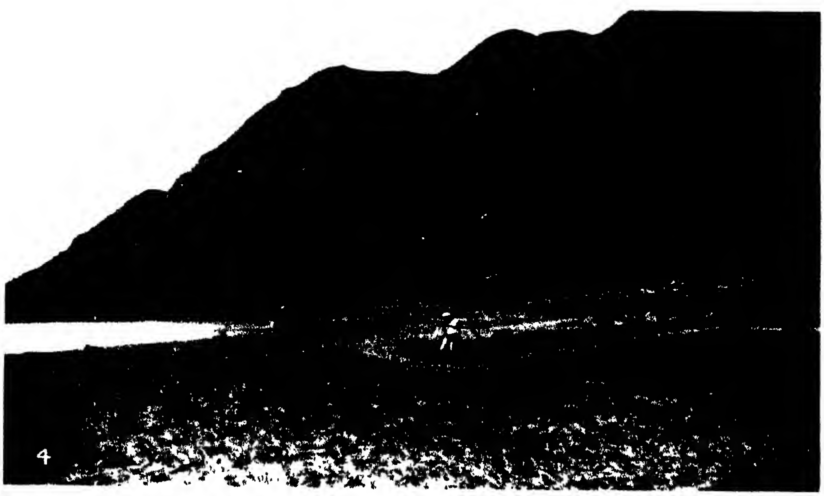
Station.	Date.	Time.	Locality.	Gear.	Notes.
828.....	6/9/31.	—	E. end of lake.	1″ seine.	native catches.
829.....	,,	—	,,	pond-net.	shore-weeds.
831.....	,,	—	,,	long line.	native fishermen.
832.....	,,	—	,,	gun.	darter stomachs.
833.....	7/9/31.	1200.	centre of lake.	plankton-nets.	depth 4 m., horizontal hauls.
834.....	6/9/31.	—	E. end of lake.	2″ gill-nets.	near weeds.
835.....	7/9/31.	—	,,	—	native fishermen.
836.....	,,	—	,,	pond-net.	shore-collection.

Lake Nabugabo.

Station.	Date.	Time.	Locality.	Gear.	Notes.
837.....	10/9/31.	1700–0830.	middle of lake.	gill-nets.	depth 4·5 m., lines of soundings.
839.....	12/9/31.	0600.	W. shore.	1″ seine.	sandy beach.
840.....	,,	0700.	,,	nets.	native fishermen.
841.....	,,	0900–0600.	E. shore.	gill-nets.	depth 2 m., among weeds.
842.....	12/9/31.	1100.	E. shore.	pond-net.	swampy shore.
844.....	13/9/31.	0700.	W. shore.	nets.	native fishermen.
845.....	,,	1000.	middle of lake.	plankton-nets.	depth 4·4 m., vertical hauls.
846.....	,,	1100.	,,	,,	horizontal hauls.
847.....	,,	1700–0700.	W. shore.	gill-nets.	close to shore.

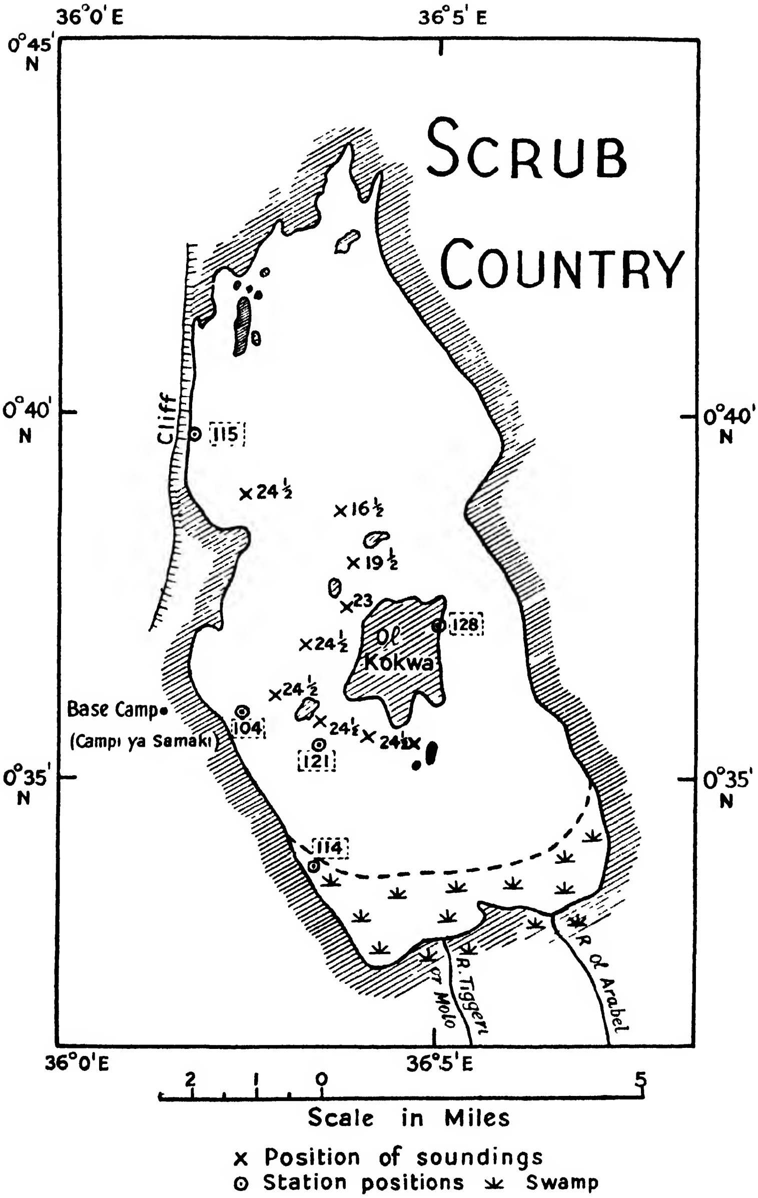


EAST AFRICAN LAKES

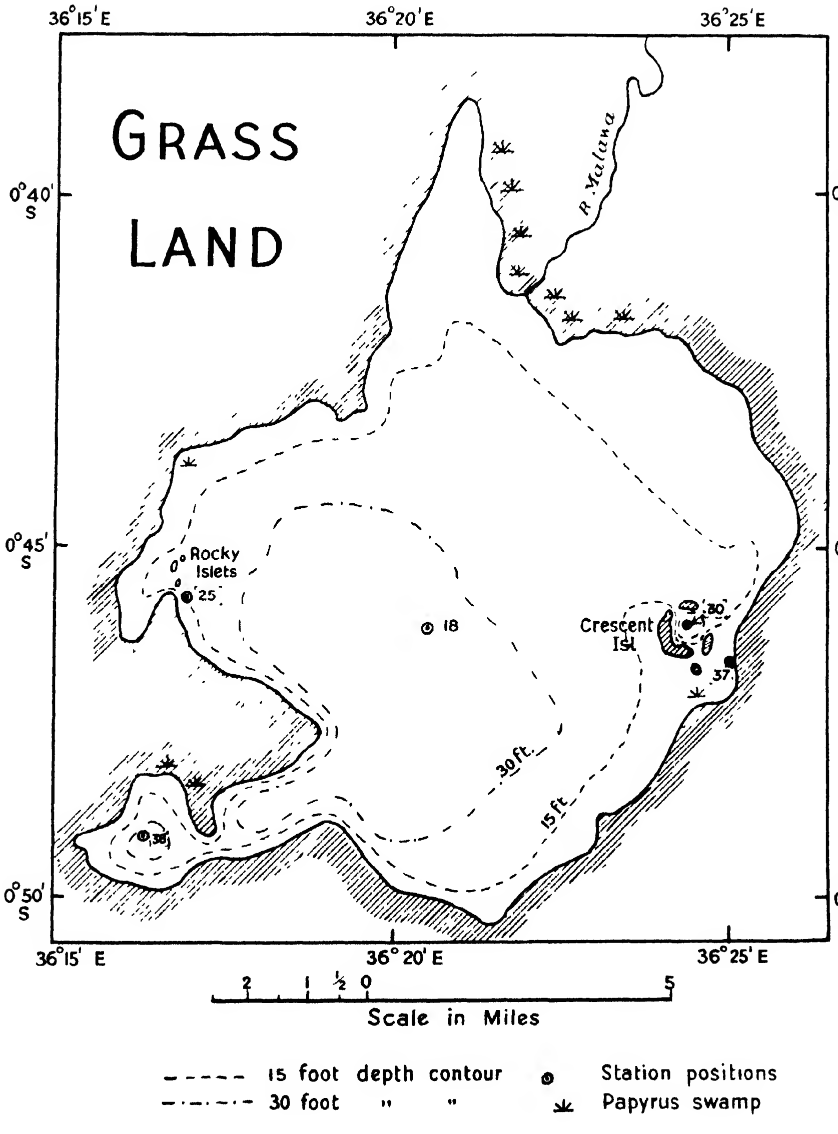


EAST AFRICAN LAKES

EAST AFRICAN LAKES



No. 4. LAKE NAIVASHA



No. 5. LAKE BUNYONI

EXPLANATION OF THE PLATES.

Plate 1.

Fig. 1. Lake Naivasha (Station 1–43). [Photo E. B. W.]

Fig. 2. Lake Kijanebalola (Stations 828–36). [Photo E. B. W.]

Plate 2.

Fig. 3. View of Lake Rudolf from the summit of Central Island, with west shore in the background. Crater lake A in foreground (Stations 270–1). [Photo S. W.]

Fig. 4. Sandspit at the foot of Mt. El Moitat, East shore of Lake Rudolf (Station 285). [Photo S. W.]

Plate 3.

Fig. 5. The western shore of Lake Edward (Stations 557–61). [Photo E. B. W.]

Fig. 6. South end of Lake George (Stations 601–4). [Photo E. B. W.]

Plate 4.

Map 1. Part of Lake Rudolf. (Expedition survey by S. Worthington.)

Map 2. Lakes Edward and George.

Map 3. The East African Lakes.

Plate 5.

Map 4. Lake Naivasha. Shore outline and some of depth contours from a survey (Kenya Colony, P.W.D., no. 4920) by Mr. H. C. H. Jones.

Map 5. Lake Bunyoni. Shore outline from Africa, 1 : 250,000, $\frac{\text{North A.37}}{5}$ 1914.

Scientific results of the Cambridge Expedition to the East African Lakes, 1930–1.—2. Fishes other than Cichlidae. By E. B. Worthington, M.A., Ph.D.

(With 5 Text-figures)

Contents.

	Page
Mormyridae	122
Characinidae	123
Citharinidae	123
Cyprinidae	123
Schilbeidae	129
Cyprinodontidae	129
Centropomidae	133

The collection of non-Cichlid fishes comprises some 600 specimens. Full lists of species collected from the different lakes together with those previously recorded will be given in a subsequent paper, in which the distribution of fishes and other aquatic organisms will be related to the geological history of the lake region. The present contribution is confined to those specimens in the collection which are of systematic importance, and includes descriptions of three new *Haplochilichthys*, one new *Engraulicypris*, new subspecies of *Citharinus* (1), *Barbus* (1), and *Lates* (2), the 'lumping' of some species of *Barbus*, and other notes.

Apart from the new species, the most interesting points concern the Lake Rudolf fishes. Although the fauna of Rudolf shows undoubted similarity to that of the Lower Nile, some of the fishes differ from their Nile relatives sufficiently to warrant new names and descriptions. In order to show the relationships of these forms I have followed the policy of describing them as subspecies rather than species. As mentioned in the introduction, Lake Rudolf has been isolated from the Lower Nile since the pluvial periods, and has steadily become more alkaline as the water-level descended. The Rudolf fishes have apparently come to differ from their ancestors during this period, perhaps as a reaction to their changing physical environment.

The two new subspecies of *Lates* are particularly interesting in showing the differentiation of species from a common ancestor in the same lake. A closely parallel evolution has taken place in Lake Albert and Lake Rudolf, of which the physical conditions are very similar; in each lake the original *Lates* has become differentiated into a deep-water small form and a shallow-water large form. Tate Regan, in studying the African Cichlid fishes, has discovered many similar instances of differentiation in the absence of geographical barriers to distribution, a subject which has wide bearings on the origin of species.

The section on *Barbus altianalis*, in which it is shown that Lakes Victoria and Edward contain the same species, which is absent from the Lower Nile, affords evidence for the hypothesis which I have advanced that the modern fauna of Lake Edward was mostly derived from Victoria during the second pluvial period.

I am indebted to Mr. J. R. Norman for granting me every facility while studying the collection at the British Museum (Nat. Hist.), to Dr. C. Tate Regan, F.R.S., for advice in the preparation of this paper, and to Col. W. Tenison for drawing the figures.

Note concerning measurements :—

'Length' is measured in all cases from the tip of the upper lip to the root (not tip) of the caudal fin. In a previous paper (1929) I sometimes used the term 'total length' for this same measurement. 'Total length' should be restricted to the over-all measurement, including the caudal fin, and is not used in this paper.

'Length of head' is measured from the tip of the upper lip to the hind extremity of the opercular bones (in *Lates* to the tip of the opercular spine); it does not include the flap of opercular skin which sometimes extends behind the bone.

'Length of snout' is measured from the tip to the anterior border of the eye.

'Length of caudal peduncle' is measured to the hind end of the fleshy part of the tail; it does not include the basal part of the caudal fin, which in some forms is clothed with scales.

'Dorsal spines' are measured from the basal articulation, not from the upper extremity of muscle or scales.

MORMYRIDAE.

Mormyrus caschive L.

Two specimens from sta. 619, Lake George, and sta. 501, Kazinga Channel, have been placed in this species, though they differ from typical specimens from the Lower Nile in the following characters :—Dorsal 71 to 74 (instead of 76 to 90), $5\frac{2}{3}$ times as long as anal and $1\frac{1}{8}$ times as long as its distance from end of snout. Anal 17 to 18. Caudal peduncle $1\frac{1}{3}$ to $1\frac{1}{2}$ times as long as deep. Scales very small, 120 to 130 in lateral line, 28 to 32 round caudal peduncle.

Originally this species was supposed to be confined to the Lower Nile and Bahr-el-Jebel, but in 1928 I obtained it from Lake Albert, and the two specimens extend its distribution from the Lower Nile to Lakes Edward and George.

Mormyrus kannume Forsk.

One specimen from sta. 501, Kazinga Channel, belongs to this species, but differs from the species elsewhere in having 32 (instead of 26 to 30) scales round the caudal peduncle. The species was previously known in the Nile system from the delta to Lake Victoria.

CHARACINIDAE.

ALESTES NURSE (Rüpp.).

A small species of *Alestes* is abundant near the Lake Rudolf shores, of which 49 specimens were preserved from stas. 240, 245, 275, and 278. There is no important structural difference between these specimens and *A. nurse* from elsewhere, but in Lake Rudolf the species grows no longer than 50 mm., sexual maturity being reached at about 40 mm., compared with 200 mm. usually attained by the species in other waters. Furthermore, the Rudolf specimens show no indication of the dark markings on the caudal peduncle and behind the operculum, which are typically developed in specimens from other waters.

CITHARINIDAE.

CITHARINUS CITHARUS (Geoffr.) INTERMEDIUS, subsp. n.

Depth of body $1\frac{3}{5}$ to $1\frac{5}{6}$ times in length, length of head $3\frac{1}{5}$ to $3\frac{1}{4}$ times. Head $1\frac{5}{6}$ to twice as long as broad, upper profile concave ; snout a little longer than eye, projecting beyond mouth ; eye $4\frac{1}{2}$ to $5\frac{1}{5}$ times in length of head, interorbital width 2 to $2\frac{1}{6}$ times. Dorsal 19 to 20 (4 to 6 unbranched). Base of adipose fin $\frac{5}{6}$ to once its distance from dorsal. Anal 26 to 29 (3 unbranched). Caudal deeply forked, its peduncle a little deeper than long. Scales 88 to $92\frac{23-25}{23-25}$, 18 to 20 between lateral line and root of pelvic.

Five specimens from stas. 207, 219, 222, and 229, Lake Rudolf, in length from 235 to 315 mm.

This Rudolf form of *Citharinus* is interesting in that it takes an intermediate position between the two species *C. citharus* and *C. latus* M. & T. from the lower Nile ; hence its subspecific name. The scaling, fin-rays, and eye pronounce it to be nearer to *C. citharus* ; the size of the adipose fin is intermediate ; the depth of the body and the width of the head are as in *C. latus*.

CYPRINIDAE.

BARBUS BYNNI (Forsk.) RUDOLFIANUS, subsp. n.

Depth of body $2\frac{3}{4}$ to 3 times in length, length of head 4 to $4\frac{1}{4}$ times. Snout $3\frac{1}{4}$ to $3\frac{1}{3}$ times in length of head, eye $4\frac{1}{4}$ to $4\frac{1}{2}$ times, interorbital width $2\frac{7}{8}$ to 3 times ; mouth inferior, lower lip interrupted on the chin except in one specimen ; two very short barbels on each side, anterior $\frac{1}{3}$ to nearly $\frac{1}{2}$ diameter of eye, posterior $\frac{3}{5}$ to $\frac{2}{3}$. Dorsal IV 9, equally distant from occiput and from root of caudal, last simple ray very strong, bony, not serrated, $1\frac{1}{3}$ to $1\frac{1}{2}$ times length of head. Anal III 5, not quite reaching caudal. Pectoral $\frac{3}{4}$ to $\frac{7}{8}$ as long as head ; first ray of pelvic anterior to origin of dorsal. Caudal peduncle $1\frac{1}{4}$ times as long as deep. Scales longitudinally striated, 35 to 37 $\frac{6\frac{1}{2}-7\frac{1}{2}}{5\frac{1}{2}}$, $2\frac{1}{2}$ to 3 between lateral line and pelvic ventral, 16 round caudal peduncle. Steel-blue above, white beneath.

Four specimens from stas. 215, 299, Lake Rudolf, measuring from 235 to 295 mm. in length.

I have not created a new species for these specimens, since I am convinced that the species of *Barbus* are much more variable than has been recognized previously. *B. ruspolii* Blgr. from Lakes Abaia and Ganjule, which *B. bynni rudolfianus* resembles, should also in my opinion be a subspecies of *B. bynni*. Furthermore, the new subspecies connects *B. bynni* with *B. meneliki* Pellegr., of which only the type is known from Lake Rudolf (Paris Museum). The latter also has short barbels and interrupted lips, but is distinct in having larger scales.

Barbus gregorii Blgr.

Unfortunately only young specimens had previously been collected from the Baringo drainage system, which were made the types for this species together with one specimen from the upper Tana river (Boulenger, 1902). Nine other young specimens from Lake Baringo itself were placed by Boulenger with *Barbus bynni* by reason of their long dorsal spines. During the expedition many hundred specimens were examined and a series of 37 were preserved, ranging in length from young specimens 90 mm. long to adults of 370 mm. The range of variation in this series is such as to embrace the old specimens which had been separated as *B. bynni*, and necessitates the redescription of *B. gregorii*, which is now the only known species of *Barbus* in Lake Baringo :—

Depth of body 3 to $3\frac{3}{4}$ times in length, length of head $3\frac{3}{5}$ to $4\frac{1}{3}$ times. Snout rounded or subacuminate, 3 to $3\frac{1}{2}$ times in length of head ; eye 4 (young) to 7 times in length of head, interorbital width $2\frac{2}{3}$ to $3\frac{2}{3}$ times ; mouth inferior, its width 3 to $4\frac{1}{2}$ times in length of head ; lips exhibiting considerable variation in degree of development, but never produced into large fleshy lobes, and the lower always continuous across the chin ; two barbels on each side, anterior $1\frac{1}{3}$ to $1\frac{4}{5}$ diameter of eye, posterior $1\frac{1}{2}$ to 2. Dorsal III to IV 8 to 9, equally distant from occiput or eye and from root of caudal, border concave ; last simple ray very strong, bony, not serrated, $\frac{3}{5}$ (adult) to $1\frac{1}{5}$ (young) length of head. Anal III 5, reaching or nearly reaching caudal. Pectoral $\frac{4}{5}$ to once length of head, not reaching pelvic ; base of latter below anterior rays of dorsal. Caudal peduncle 1 to $1\frac{2}{5}$ as long as deep. Scales longitudinally striated, 29 to 34 $\frac{5\frac{1}{2}-6\frac{1}{2}}{4\frac{1}{2}-5\frac{1}{2}}$, $2\frac{1}{2}$ to 3 between lateral line and pelvic, 12 to 14 round caudal peduncle. Olive-brown above, silvery or yellow beneath.

Length up to 370 mm.

Upper Tana and Upper Hawash to the Kenya rift valley basin. Very abundant in Lake Baringo.

Barbus altianalis Blgr. (Text-fig. 1.)

Many nominal species of *Barbus* * have been described in the past owing to the paucity of specimens in early collections, and sometimes these species were based on characters such as the size of the eye and dorsal spine, which grow disharmonically with the body, so that young and adults of the same

* In this section only the large species of *Barbus* with longitudinally striated scales are considered. There are also in each lake one or more small species of the group with radiating striae on the scales, but these do not enter into the question under discussion.

species have been separated. In order to show the true relationships of the African members of the genus, it would be best in my opinion to recognize comparatively few species, with subspecies in each lake ; but for the time being it is only possible to make small alterations in the genus as large series of specimens become available for study. This involves re-descriptions and sometimes the ' lumping ' of previously described species.

In the following section the conclusion is reached that there is only one species of large *Barbus* in Lakes Victoria, Edward, George, and Kivu, which takes the name of *B. altianalis* Boulenger (1900). This is divided into three subspecies :—

B. altianalis altianalis Boulenger (1900 and 1909–16). From Lake Kivu and the Ruzizi River.

B. altianalis radcliffii Boulenger (1903 and 1909–16) and Worthington (1929). This includes Boulenger's *B. radcliffii*, *B. lobogenys*, and *B bayoni*. From Lakes Victoria, Kioga, and the Victoria Nile above the Murchison Falls.

B. altianalis eduardianus Boulenger (1901 and 1909–16). This includes Boulenger's *B. eduardianus* and *B. fergussoni*. From Lakes Edward, George, and the Kazinga Channel.

Of this last a new description is necessary :—

Depth of body 3 to 4 (rarely as much as $4\frac{1}{2}$) in length, length of head $3\frac{1}{2}$ to $4\frac{1}{2}$ times. Snout rounded, $2\frac{3}{5}$ to $3\frac{1}{2}$ times in length of head ; eye $3\frac{1}{5}$ (specimens 100 mm. long) to $6\frac{1}{2}$ (specimen 400 or more mm. long) times in length of head, interorbital width $2\frac{1}{3}$ to $3\frac{1}{5}$ times, mouth inferior, its width $3\frac{3}{5}$ to 5 times in length of head ; lips subject to great variation in size, lower one discontinuous across the chin, simply continuous, or produced into lobes ; upper one slender or thick, sometimes with a large medial lobe. Two barbels on each side, a little shorter than eye. Dorsal III–IV 9, mid-way between occiput and caudal or a little nearer to either, border usually concave ; last simple ray very strong, bony, not serrated, $\frac{1}{2}$ (adult) to once (young) in length of head. Anal III 5, reaching caudal in adult. Pectoral $\frac{3}{4}$ to nearly once length of head, sometimes reaching pelvic but usually not so, latter originating under or a little in advance of anterior rays of dorsal. Caudal peduncle $1\frac{1}{4}$ to $1\frac{3}{5}$ as long as deep. Scales longitudinally striate, 33 to 39 $\frac{5\frac{1}{2}-7\frac{1}{2}}{4\frac{1}{2}-5\frac{1}{2}}$, $2\frac{1}{2}$ to $3\frac{1}{2}$ between lateral line and pelvic, 12 to 14 round caudal peduncle. Olive-brown above, pale beneath, scales darker at the base.

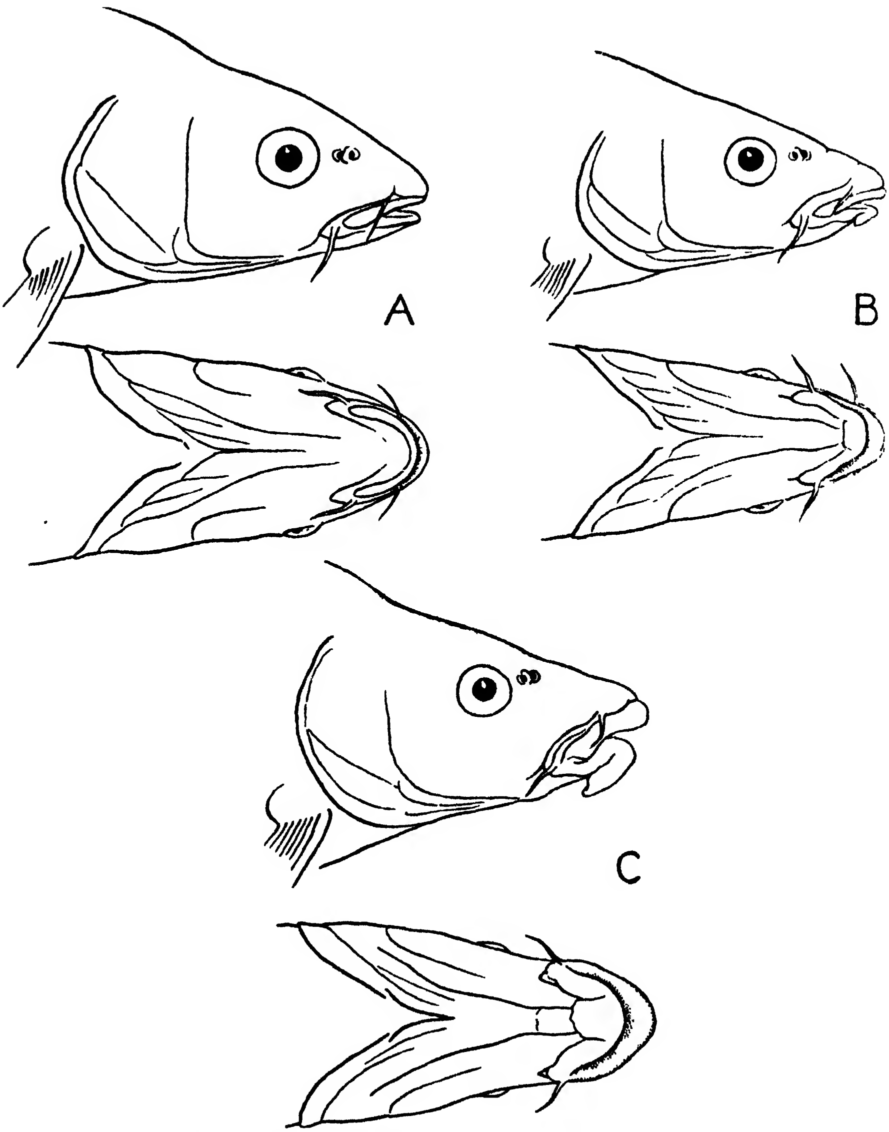
Length up to about 500 mm. (heads only of the largest specimens preserved).

The description includes the type (adult specimen) of *B. eduardianus* Blgr. (1901), the two types (half-grown specimens) of *B. fergussoni* Blgr. (1901), five specimens collected by Dr. J. C. Phillips in 1924 and identified as *B. fergussoni* (1 specimen) and *B. altianalis* (4 specimens) by Norman (1925), and 41 specimens ranging from young fish 80 mm. long to adults 400 and 500 mm. collected by the Cambridge Expedition in 1931. All of these form a harmonious series overlapping Boulenger's two species, the most common form being an intermediate between the two.

From the new series of specimens there comes an important conclusion concerning the African species of the genus *Barbus*. In 1929 I showed that

B. altianalis radcliffii exhibits remarkable variation in the degree of development of the lips, and therefore that the separation of species into those with continuous

Text-fig. 1.



Barbus altianalis eduardinus Boulenger, to show lip variation.

A. $\frac{1}{3}$ nat. size. B. $\frac{1}{3}$ nat. size. C. $\frac{1}{4}$ nat. size.

lower lips and those with interrupted lower lips in Boulenger's key cannot stand. Now the new series from Lake Edward is found to exhibit a precisely

similar lip-variation from interrupted to gross development (fig. 1). This conclusion may well be applied to other species within the genus. Thus, when a large series of specimens is collected from Lake Tsana and the upper tributaries of the Blue Nile, it is probable that the series of species endemic to that region—*Barbus leptosoma, degeni, nedgia*, etc.—will prove to be one and the same species, since they differ from each other almost solely in the degree of lip-development and in the size of eye and dorsal spine.

With reference to *B. altianalis altianalis* from Lake Kivu, Norman (1925) expressed the opinion that it is identical with *B. a. radcliffii* from lake Victoria. The two are undoubtedly the same species, but I prefer to retain the Kivu specimens as a subspecies.

At first sight it seems anomalous that the *Barbus* from Lake Kivu is so similar to those from Edward and Victoria, since Kivu is now drained by the River Ruzizi to Lake Tanganyika and so to the Congo. This is explicable, however, by the late geological history of Central Africa, because until quite recently Lake Kivu was the valley of a river which flowed northward to Lake Edward (via the river Ruchuru) to the Nile. The Mfumbiro volcanoes were built up across this river, damming it until the ponded valley overflowed at the south end and cut the Ruzizi canyon.

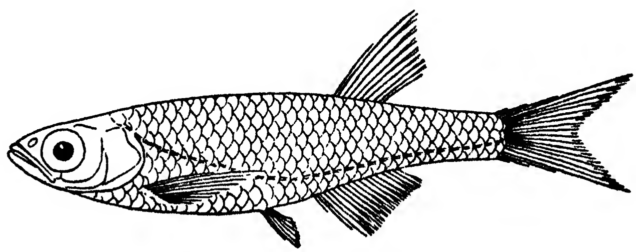
The relationship between the three subspecies is shown in the following table of characters :—

Character.	*B. a. radcliffii.*	*B. a. eduardianus.*	*B. a. altianalis.*
$\frac{\text{Length}}{\text{Depth}}$	3 to $4\frac{1}{5}$	3 to $4\frac{1}{2}$	4 to $4\frac{1}{2}$
$\frac{\text{Length}}{\text{Length of head}}$	3 to $4\frac{1}{5}$	$3\frac{1}{2}$ to $4\frac{1}{2}$	4 to $4\frac{1}{2}$
$\frac{\text{Length of head}}{\text{Length of snout}}$	$2\frac{3}{5}$ to $3\frac{1}{2}$	$2\frac{3}{5}$ to $3\frac{1}{2}$	3 to $3\frac{1}{2}$
$\frac{\text{Length of head}}{\text{Diam. of eye}}$	$3\frac{1}{3}$ (yng.) to 7	$3\frac{1}{5}$ (yng.) to $6\frac{1}{2}$	5 to $5\frac{1}{2}$
$\frac{\text{Length of head}}{\text{Interorbital width}}$	$2\frac{1}{2}$ to 3	$2\frac{1}{3}$ to $3\frac{1}{5}$	$2\frac{2}{3}$ to $2\frac{4}{5}$
$\frac{\text{Length of head}}{\text{Width of mouth}}$	3 to 4	$3\frac{2}{3}$ to 5	4
$\frac{\text{Length of barbels}}{\text{Diam. of eye}}$	$\frac{2}{3}$ to 1	$\frac{3}{4}$ to 1	$1\frac{1}{5}$ to $1\frac{1}{2}$
$\frac{\text{Length of head}}{\text{Length of longest dorsal ray}}$.	$\frac{1}{2}$ to $\frac{3}{4}$	$\frac{1}{2}$ to 1	$\frac{1}{2}$ to $\frac{3}{4}$
$\frac{\text{Length}}{\text{Depth}}$ of caudal peduncle ..	$1\frac{1}{3}$ to $1\frac{3}{4}$	$1\frac{1}{4}$ to $1\frac{4}{5}$	$1\frac{2}{3}$
Scales in lateral line	32 to 36	33 to 39	34 to 35

Engraulicypris stellae, sp. n. (Text-fig. 2.)

Depth of body 4 to 5 times in length, length of head $3\frac{3}{4}$ to 4 times. Head 2 to $2\frac{1}{4}$ times as long as broad ; snout pointed, not projecting beyond mouth, shorter than eye, which is three times in length of head and equals interorbital width ; mouth extending to below anterior third of eye ; suborbitals covering greater part of cheek. Gill-rakers short, 10 on lower part of anterior arch. Dorsal II 7 to 9, its origin distinctly behind that of the anal, $1\frac{4}{5}$ to 2 times as distant from end of snout as from caudal ; first branched ray longest ; $\frac{2}{3}$ to $\frac{3}{4}$ length of head. Anal III 14 to 16. Pectoral acutely pointed, reaching pelvic (except in young). Caudal deeply forked. Caudal peduncle twice as long as deep. Scales 34 to 37 $\frac{4\frac{1}{2}-5\frac{1}{2}}{2\frac{1}{2}}$, 1 between lateral line and pelvic, 12 round caudal peduncle. Yellow above, silvery on the sides ; fins colourless.

Text-fig. 2.



Engraulicypris stellae, sp. n. × 3.

Nine specimens 20 to 23 mm. in length (types) from Lake Rudolf.
Seventeen specimens 15 to 23 mm. from sta. 220, Lake Rudolf.
Twenty-two specimens 15 to 23 mm. from sta. 247, Lake Rudolf.
Forty specimens 12 to 21 mm. from sta. 251, Lake Rudolf.
Thirteen specimens 10 to 18 mm. from sta. 259, Lake Rudolf.
One specimen 25 mm. from sta. 283, Lake Rudolf.
Seven specimens 18 to 23 mm. from sta. 287, Lake Rudolf.

This species is closely related to *E. minutus* from Lake Tanganyika, differing particularly in the larger head and eye. In some respects it is intermediate between *E. minutus* and *E. bottegi* from the regions north of Lake Rudolf, but differs markedly from the latter in the larger head, smaller scales, and the backward situation of the dorsal fin.

Specimens from 22 to 25 mm. long were sexually adult, so it is unlikely that the new species grows to a greater length than those collected. This is the smallest but in many ways the most important fish in Lake Rudolf. It leads a pelagic existence, feeding directly on the zooplankton, and so puts a valuable food-supply into a form available for larger fishes.

The specific name is in honour of my wife, who was a member of the expedition and has assisted greatly in the fish researches.

SCHILBEIDAE.

SCHILBE URANOSCOPUS Rüpp.

Specimens from stations 215, 277, 296, and 299, Lake Rudolf, resemble this Lower Nile species in the shape of the head, which is more than $1\frac{1}{2}$ times as long as broad, and the short maxillary barbel ; but the anal rays number 63 to 67 instead of 67 to 75, in which character they resemble *S. mystus* (L.) (anal rays 53 to 67). Other characters in which the Rudolf specimens fall between *S. uranoscopus* and *mystus* are the size of the eye and the shape of the upper profile.

Many species of *Schilbe* have been described and subsequently compounded into the two—*S. mystus* and *S. uranoscopus*. Therefore I consider it best not to give this Rudolf form a new name.

CYPRINODONTIDAE.

Tate Regan (1911) pointed out that the two genera *Fundulus* Lacep. and *Haplochilus* (*Aplocheilus*) McLell. used by Boulenger (1909–16) are unnatural. Most of the species referred to *Fundulus* belong to *Nothobranchius* Peters ; and *Haplochilus* does not exist in Africa, but the species referred to it by Boulenger belong to the two genera *Panchax* Cuv. & Valenc., in which the pectoral fin is set low down on the body, and *Haplochilichthys* (*Aplocheilichthys*) Bleek., in which it is high up.

Ahl (1924, 1928) has adopted this rearrangement in general, and has created four new genera—*Fundulosoma*, *Cynopanchax*, *Platypanchax*, and *Plataplochilus*, each with one species from Africa.

The other African Cyprinodont genera, *Procatopus* Blgr. and *Lamprichthys* Regan (each with one species), having unicuspid teeth in common with all the above, and the two genera *Cyprinodon* Lacep. and *Tellia* Gerv. with tricuspid teeth stand unaltered.

The following section refers only to the genus *Haplochilichthys* characterized by an outer row of large teeth backed by several inner rows of smaller ones, and by the high-set pectoral fin.

HAPLOCHILICHTHYS PELAGICUS, sp. n. (Text-fig. 3.)

Depth of body 5 to $5\frac{3}{5}$ times in length, length of head $4\frac{3}{4}$ to $5\frac{1}{4}$ times. Head flat above ; snout $1\frac{1}{5}$ to $1\frac{2}{5}$ in diameter of eye ; eye three times in length of head, $1\frac{1}{3}$ to $1\frac{1}{2}$ times in interorbital width ; praeorbital $\frac{1}{2}$ diameter of eye. Dorsal 9 to 11 (usually 10), more than twice as distant from snout as from root of caudal, its origin above middle of anal ; anal 14 to 16 (usually 15) ; pectoral $\frac{3}{4}$ length of head, reaching to the base of pelvic ; pelvic small, $\frac{1}{2}$ length of head, much nearer tip of snout than root of caudal. Caudal truncate, as long as head, with a marked black fringe. Caudal peduncle $2\frac{1}{3}$ to $2\frac{2}{3}$ times as long as deep. 36 to 39 scales in longitudinal series, 22 to 24 round body in front of pelvics.

In life rather bright yellow, with an obvious black fringe to the tail, a black patch on the crown, and a dark streak down the lateral line (all of which persist in alcohol).

Nine specimens 41 to 48 mm. in length (types) from sta. 552, Lake Edward.

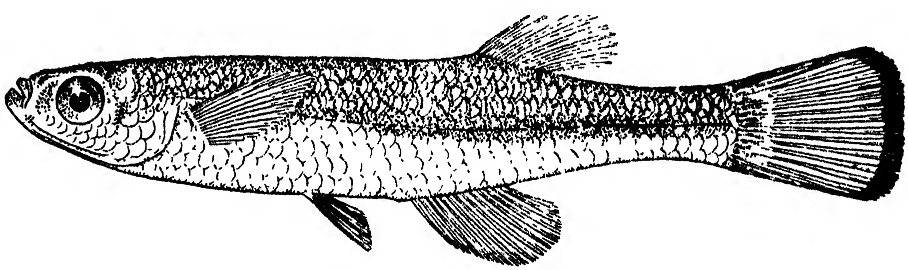
Twenty-six specimens 40 to 48 mm. in length from sta. 552, open water of Lake Edward, taken near the surface.

Seven specimens 40 to 45 mm. in length from sta. 561, pelican stomachs.

This new species occupies an isolated position, differing from all other species in the smaller scales (36 to 39 in longitudinal series ; no other species has more than 34) and other characters. It is, in fact, one of the very few species of Cyprinodonts which can be named at a glance, since it differs so much from its relatives not only in the scales and proportion of body but in the square-ended tail with a marked black fringe.

Furthermore, the new fish is, so far as I know, the only member of the family which has an essentially pelagic habitat with the partial exception of *H. antinorii*

Text-fig. 3.



Haplochilichthys pelagicus, sp. n. × 2.

from Lake Naivasha, its nearest relative (see p. 132). It lives only in the open deep water of Lake Edward, feeding on planktonic crustacea at the surface. For this reason I have named it *H. pelagicus*. Its role in the ecology of Lake Edward will be discussed in a later paper.

Haplochilichthys analis, sp. n. (Text-fig. 4.)

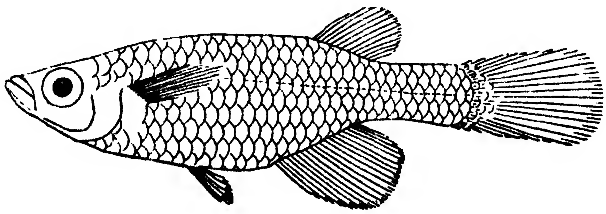
Depth of body $3\frac{1}{5}$ to $3\frac{3}{4}$ times in length, length of head 4 to $4\frac{1}{5}$ times. Head flat above ; snout $1\frac{1}{3}$ in diameter of eye ; mouth directed upward ; eye $2\frac{3}{5}$ to $2\frac{4}{5}$ times in length of head, $1\frac{2}{5}$ to $1\frac{3}{4}$ in interorbital width ; preorbital $\frac{1}{3}$ in diameter of eye. Dorsal 12 to 13, $2\frac{1}{2}$ to 3 times as distant from snout as from root of caudal, its origin above middle of anal ; anal 19 to 21 ; pectoral $\frac{3}{4}$ length of head, reaching beyond base of pelvic ; pelvic less than $\frac{1}{2}$ length of head, considerably nearer tip of snout than root of caudal. Caudal more or less truncate, as long as head. Caudal peduncle $1\frac{3}{5}$ to $1\frac{4}{5}$ times as long as deep. 31 to 32 scales in longitudinal series ; 22 to 24 round body in front of pelvics.

A uniform pale yellow colour with a dark patch on the crown. Fins pale.

Fourteen specimens 21 to 33 mm. in length (types) from sta. 522, Rivers Niamweru and Ruampuno flowing into Lake Edward from the East.

Two adults (31 to 33 mm.) and four young (14 to 20 mm.) from a river near Malabunde, Congo, which debouches into the upper reaches of the Semliki River above the Semliki Falls. All collected by L. C. Beadle.

TEXT-FIG. 4.



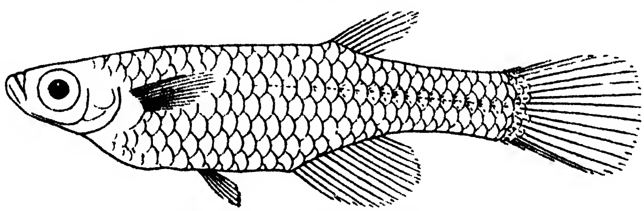
Haplochilichthys analis, sp. n. × 2.

This species occupies an isolated position in the genus. Like *H. stuhlmanni* Ahl., it has about 20 anal fin rays (no other species have so many), but it can be easily distinguished from *H. stuhlmanni* by the dorsal fin, which has 12 to 13 instead of six rays.

HAPLOCHILICHTHYS RUDOLFIANUS, sp. n. (Text-fig. 5.)

Depth of body 4 to 4⅛ times in length, length of head 4⅛ to 4⅓ times. Head flat above; snout very short, ½ to ⅗ length of eye; mouth directed upward, lower jaw projecting; eye 2⅗ times in length of head, 1⅕ to 1⅗ in interorbital width, a little shorter than postorbital part of head; praeorbital ⅓ diameter of eye. Dorsal 8, twice as distant from snout as from root of caudal, above

TEXT-FIG. 5.



Haplochilichthys rudolfianus, sp. n. × 2½.

middle of anal; longest rays about ⅔ length of head; anal 14 to 15; pectoral about ⅘ length of head, extending to base of pelvic; pelvic ½ length of head, much nearer tip of snout than root of caudal. Caudal subtruncate, a little longer than head. Caudal peduncle 2 to 2⅕ times as long as deep. 28 to 29 scales in longitudinal series, 16 to 18 round body in front of pelvics. Yellow above, pale beneath, the scales finely edged with black; fins colourless.

Three specimens 21 to 26 mm. in length from sta. 213, west shore of Lake Rudolf (types).

One young specimen 15 mm. from sta. 286, east shore of Lake Rudolf.

So far as I know, these are the only Cyprinodonts yet collected from Lake Rudolf. Like all the Rudolf fishes, this little species has close relations in Lake Albert and the lower Nile. The two nearest to it are *H. schoelleri* Blgr. from Egypt, from which it differs in the shorter snout, narrower interorbital, and 14 to 15 instead of 12 to 13 anal rays, and *H. kassenjiensis* Ahl from Lake Albert, from which it differs in the shorter snout, narrower interorbital, longer caudal peduncle, and 28 to 29 instead of 24 to 26 scales in longitudinal series.

HAPLOCHILICHTHYS PUMILUS (Blgr.).

A series of five specimens from sta. 812, Lake Nakavali, are indistinguishable from Boulenger's types. A further series of 13 specimens from the same station are more like *H. myaposae* Blgr., a very closely related species, of which only the types from Zululand are known. In view of the fact that the former series have proved on dissection to be males and the latter to be females, and that both kinds were collected together, I am convinced that the difference (which consists almost solely in the shape of dorsal and anal fins) is merely a secondary sexual character.

H. pumilus is a widely distributed species, now known from Lakes Victoria, Tanganyika, Nakavali, and George (see below), and therefore might well occur in Zululand also ; but it cannot be quite certain that *H. pumilis* and *H. myaposae* are the same species until males have been discovered in Zululand for comparison.

A single specimen 31 mm. long from sta. 615, Lake George, is almost certainly this species, differing only in the greater length of the pelvic fin and in the pale colour. A further series of 4 specimens, 16 to 28 mm. long, from sta. 617, Lake George, differ from *H. pumilus* in having a rather larger eye and longer caudal peduncle, but their state of preservation is not sufficiently good to warrant their description as types.

HAPLOCHILICHTHYS ANTINORII Vincig.

This species was originally described from Southern Ethiopia, and subsequently specimens were referred to it from Lake Naivasha, where it is the only indigenous fish. There is a long series of specimens now in the British Museum (Nat. Hist.) from Lake Naivasha, all of which differ from *H. antinorii* as found elsewhere, particularly in the markedly truncate tail. Though there is no need to separate this form as a different species, I would point out that Lake Naivasha has been isolated from other African waters ever since the Gamblian (2nd) pluvial period, and the difference between specimens from the lake and typical *H. antinorii* may be attributed to this long period of isolation.

The habitat of this species in Lake Naivasha is among the shore-weeds of the shallow water, where the colour is very dark, being almost black in the male. In 1930, however, we discovered a bottom-living race in the open water, living at a depth of 6 to 19 metres. This has taken on the appearance of an abyssal

fish, very pale in colour with a large prominent black eye (1 instead of 1⅓ in interorbital width). In other respects it is the same as the shallow-water fish, except that the truncation of the caudal fin is still more marked. The specimens are not sufficiently numerous or in a good enough state of preservation to warrant their description as new, but the two forms of *Haplochilichthys* in Lake Naivasha provides an interesting parallel to the deep and shallow water forms of *Lates* in Lake Rudolf and Lake Albert.

CENTROPOMIDAE.

LATES NILOTICUS (L.).

In 1929 I described two new species of *Lates* from Lake Albert. *L. albertianus* grows to a length of 150 cm., becomes sexually adult at about 70 cm. length, and lives near the shores ; whereas *L. macrophthalmus* is much smaller, growing only to a length of some 50 cm. and becoming adult at about 25 cm. ; it lives at the bottom in the open water at a depth of 20 to 45 metres. Both these species were found to be distinct from *L. niloticus*, a river-species from the Lower Nile.

In 1931 a large number of *Lates* were caught in Lake Rudolf. The larger specimens could not be preserved, but measurements were made in the field, and a series of medium-sized specimens were preserved and brought to England. As in the case of the Lake Albert *Lates*, these also fall into two groups—a very large form in the inshore waters and a small form in the deep open water. These two, though distinct from each other, overlap the three species from Lake Albert and the Lower Nile ; the larger form falls roughly midway between *L. niloticus* and *L. albertianus*, and the small deep-water form is between *L. albertianus* and *L. macrophthalmus*. For these reasons, and following my policy with regard to the other Rudolf fishes, I describe the two forms as subspecies of *L. niloticus* :—

LATES NILOTICUS RUDOLFIANUS, subsp. n.

Depth of body 2⅘ to 3⅖ (4 in very large specimens) in length ; length of head 3 to 3¼ times.

Upper profile of head slightly concave. Snout rounded, its length 1¼ times diameter of eye (equals eye in very young, 3 times eye in very large specimens) ; eye large, 4 times (specimens of 100 mm.), 5 times (specimens of 300 mm.) to 12 times (very large specimens) in length of head, ⅔ to once in interorbital width (2⅓ in very large specimens). Maxillary extending to behind posterior border of eye except in very young specimens. Orbitals, opercula, and clavicle as in *L. niloticus*. Third dorsal spine the longest, ⅗ to ¾ length of head, once to 1⅓ times as long as fourth spine. Pectoral ½ to ⅔ length of head. Caudal peduncle 1⅕ to 1⅗ as long as deep. Scales 68 to 75 in lateral line.

Length of preserved specimens up to 380 mm. ; grows to 1480 mm.

The description is based on seven preserved specimens from stas. 212, 214, 255, 285, and 286, Lake Rudolf, ranging in length from 100 to 380 mm. and from measurements on 34 large specimens from 67 to 148 cm. made in the field.

LATES NILOTICUS LONGISPINIS, subsp. n.

Differing from the last in the following characters :—depth of body $3\frac{1}{5}$ to $3\frac{1}{2}$ in length, length of snout $\frac{2}{3}$ diameter of eye (specimens of 120 mm.) to once (specimens of 270 mm.) ; eye large, $3\frac{1}{5}$ (specimens of 120 mm.) to $4\frac{4}{5}$ (specimens of 270 mm.) in length of head, $\frac{2}{5}$ to $\frac{3}{4}$ in interorbital width. Maxillary not, or only just, extending to below posterior border of eye. Third spine of dorsal very long, $\frac{3}{4}$ to once length of head, $1\frac{1}{3}$ to $1\frac{1}{2}$ as long as fourth spine. Pectoral $\frac{5}{8}$ length of head. Caudal peduncle $1\frac{1}{2}$ to $1\frac{3}{5}$ as long as deep. Scales 65 to 71 in lateral line.

Length up to 275 mm.

The description is based on six specimens from stas. 215, 226, and 267, Lake Rudolf, ranging in length form 120 to 275 mm.

REFERENCES.

AHL, E. 1924. Zur Systematik der altweltlichen Zahnkarpfen der Unterfamilie Fundulinae. Zool. Anz. Bd. 60, pp. 49–55.

——. 1928. Beitrage zur Systematik der afrikanischen Zahnkarpfen. Zool. Anz. Bd. 79, pp. 113–23.

BOULENGER, G. A. 1900. Diagnoses of new Fishes discovered by Mr. J. E. S. Moore in Lake Tanganyika. Ann. & Mag. Nat. Hist. (7) vi, pp. 478–81.

——. 1901. Diagnosis of Four new Fishes discovered by Mr. J. E. S. Moore in Lakes Albert and Albert Edward. Ann. & Mag. Nat. Hist. (7) viii, pp. 12–14.

——. 1902. Descriptions of new Fishes from the Collection made by Mr. E. Degen in Abyssinia. Ann. & Mag. Nat. Hist. (7) x, pp. 422–39.

——. 1903. Descriptions of Two new Fishes discovered by Major C. Delmé Radcliffe in the Victoria Nyanza. Ann. & Mag. Nat. Hist. (7) xii, pp. 218–19.

——. 1909–1916. Catalogue of the Freshwater Fishes of Africa. Brit. Mus. (Nat. Hist.).

NORMAN, J. R. 1925. A new Siluroid Fish of the Genus *Clarias* from South-western Uganda. Occasional Papers, Boston Soc. Nat. Hist. vol. v, pp. 189–90.

REGAN. C. TATE. 1911. The Osteology and Classification of the Teleostean Fishes of the Order Microcyprini. Ann. & Mag. Nat. Hist. (8) vii, pp. 320–27.

WORTHINGTON, E. B. 1929. New Species of Fish from the Albert Nyanza and Lake Kioga. Proc. Zool. Soc. London, 1929, pp. 429–40.

Scientific results of the Cambridge Expedition to the East African Lakes, 1930–1.—3. Observations on the bionomics of some East African Swamps.

By L. C. Beadle. (Communicated by Dr. E. B. Worthington, F.L.S.)

(With 6 Text-figures)

Introduction.

The bionomics of a tropical swamp were investigated in some detail in the Paraguayan Chaco of South America in 1926–7 (Carter and Beadle, I, II, and III). Certain chemical and physical conditions of the water were examined as being possible limiting factors in the distribution of the fauna.

In comparing the swamps themselves with certain open and unshaded rain-pools it was found that the latter could support at all depths a large number of planktonic organisms, while the swamps were practically devoid of phyto-plankton, and the zooplankton was by comparison scarce, and was living only in the surface-layer of water. In a study of the chemical and physical conditions of these two environments this difference could only be attributed to the much lower oxygen content of the swamp water. During the hot months as little as 0·2–0·3 c.cm. of oxygen per litre, and very often none at all, was found in samples taken from as near the surface of the swamp as possible, while at a depth of about 4 inches none was ever detected during this period.

This condition was not only responsible for the scarcity of the zooplankton, but was also reflected in a number of adaptations to aerial respiration among the fauna. No satisfactory explanation was found for the lack of phyto-plankton in the swamp water.

The conclusions drawn from this work were that the condition of low oxygen content of the water is probably typical of stagnant tropical waters and that the development of the air-breathing habit in fishes, which must also have taken place during the evolution of the terrestrial vertebrates, was a result of this condition and did not, as generally supposed, originate from the habit of migrating out of the water, which at least some of these fishes undoubtedly do.

It was obviously of importance that further evidence should be obtained from similar waters in the tropics of another continent. An opportunity for this was offered in 1930–1 during the course of the 'Cambridge Expedition to the East African Lakes' (led by Dr. E. B. Worthington).

The main object of this expedition was a biological survey of certain large lakes, and this work demanded most of the available time and necessitated moving about from place to place. It was, therefore, not possible to make a continuous and thorough examination of any one swamp. The few scattered observations recorded in this paper were made in three different places in East

Africa, one in swamps bordering Lake Naivasha in Kenya, and two in swamps in the Kazinga Channel which connects Lakes Edward and George in Uganda.

The value of a comparison between these three places is enhanced by the fact that the first (Lake Naivasha), though in general a swamp of similar appearance to the other two and situated near the Equator, is, as the meteorological observations clearly show, not subjected to truly tropical conditions, being at an altitude of 6,200 feet. The two Uganda swamps are 3000 feet above sea-level, and the climate is therefore more truly tropical, though the temperatures were not as high as those of the Paraguayan Chaco (altitude under 100 feet).

A general idea of the nature and richness of the fauna and flora of these waters will also be given. It was, however, impossible, owing to the difficulty of collecting with a hand-net in water in which dense vegetation was growing, to get any but a rough idea of the relative density of the plankton in different places. But the differences were often so striking that the roughest collecting methods were sufficient to show them.

More detailed descriptions of these lakes, together with complete records of the observations, will be published in another paper, p. 157 of this volume. Only those points which are relevant to the present problem will be recorded in this paper.

Methods.

The following determinations were made :—

(1) Temperature.
(2) Alkalinity.
(3) Hydrogen-ion concentration.
(4) Phosphate content.
(5) Oxygen content.
(6) Amount of Iodine absorbed.

The methods used, except for no. 6, were identical with those employed by Carter and Beadle (I, p. 217).

The amount of iodine absorbed by a given volume of water-sample was not determined in the Paraguayan Chaco. It was done on the Uganda lake-waters as an indication of the amount of sulphide (including free H_2S) present. The method used was a modification of that described by Thresh and Beale (1925, p. 313). The quantity of iodine absorbed from a standard solution by a known volume of the acidified sample is equivalent to the amount of sulphide present. Excess of N/100 iodine was added to 100 c.cm. of sample and the residual (unabsorbed) iodine was estimated by titration with standard sodium thiosulphate, using starch as an indicator. During the course of the work it became evident that, since the Winkler method of oxygen determination entails the estimation of iodine which is produced in an amount equivalent to the oxygen content of the sample, the figure obtained by this method would be subject to error if the water contained a significant amount of sulphide, a condition

which might be expected in stagnant swamp waters. The water might in reality be richer in oxygen than would be supposed from the Winkler determination.

This complication was, unfortunately, not realized until the end of the expedition, and only one swamp was examined with this in view. Alsterberg (1926) has developed a modification of the Winkler method to obviate this source of error, which I did not discover until after the expedition had returned.

It was, however, found that the water of the swamp at Kitoma contained an amount of sulphide equivalent to 0·56 c.cm. of oxygen per litre. This was a swamp in which decay appeared to be as active as in any swamp so far investigated, and, owing to the volcanic nature of the surrounding country where sulphur springs are common, it is reasonable to assume that the sulphide content of its water was probably higher than that of the Chaco swamp waters. It is interesting to note that Ruttner, working on lakes in Java, compared figures of oxygen content obtained by the Winkler method with and without Alsterberg's modification Using water from Ranu Lamongan, which is a volcanic crater lake, he found that the greatest error incurred by using the unmodified method amounted to 1·00 c.cm. of oxygen per litre (Ruttner, 1931, p. 206). It therefore seems that the errors of the oxygen estimations by the Winkler method in these and similar swamps will always be less than 1·0 c.cm. of oxygen per litre.

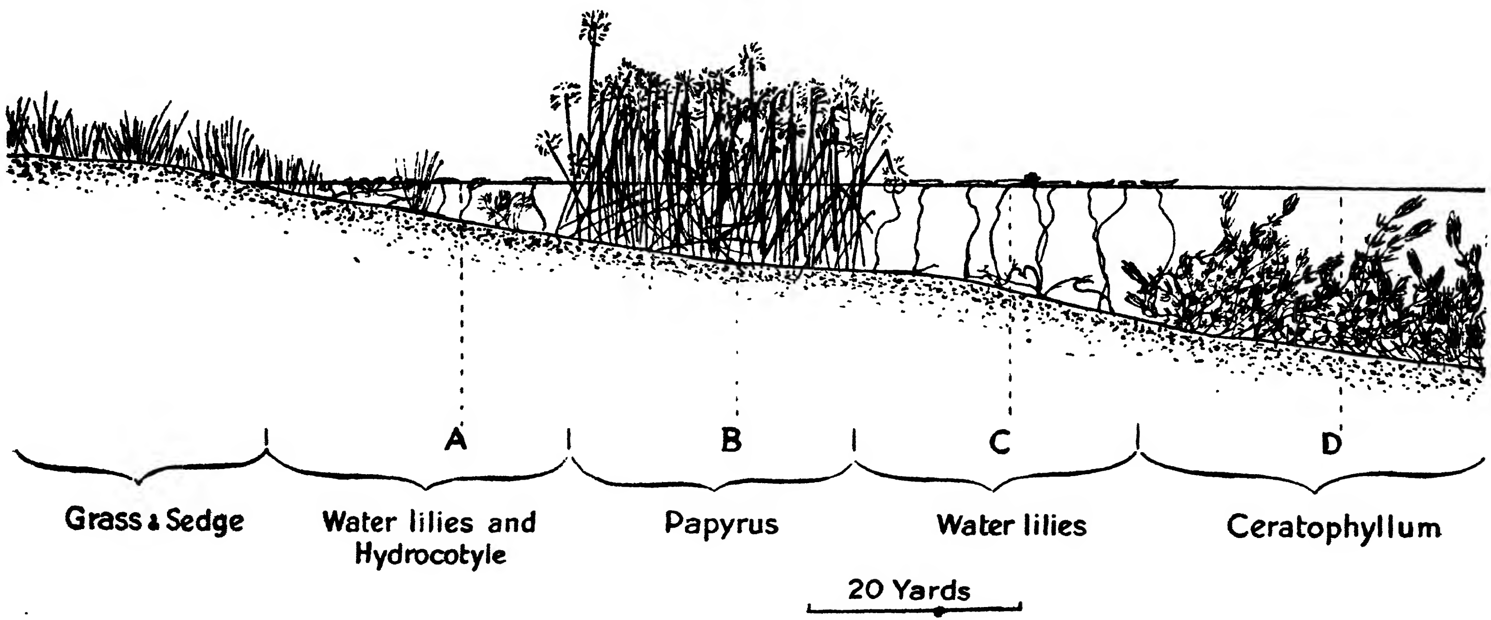
In the following results (and in the results of the work on Paraguayan swamps) some correction should be applied to the oxygen estimation. Thus a zero estimation should be regarded as one in which the oxygen present is certainly less than 1·00 c.cm per litre, and in all probability does not exceed 0·56 c.cm. per litre as was found for the Kitoma swamp.

LAKE NAIVASHA (0° 45′ S., 36° 24′ E.). (Pl. 5. Map 4.)

This is one of the Kenya Rift Valley lakes. It is situated, as has been said, at an altitude of 6,200 feet. The work described here was done in November 1930, February, March, and May 1931. Meteorological observations taken on the shore in November 1930 showed an average maximum shade temperature of 25·5° C., and an average minimum of 9·6° C. In March 1931 the average maximum was 26·9° C. and the average minimum 11·7° C. The latter figures represent the temperature range of the hot season.

In 1930–1 most of the east and north-east shores of the lake were fringed with *Papyrus* swamps of varying width. The point at which this work was done was opposite Crescent Island on the east shore, where the swamp was from 70 to 80 yards wide. A diagrammatic cross-section of the swamp at this point, showing the positions at which observations were made, is given in text-fig. 1. At A the water was about 6 inches deep, it was nearly covered with water-lilies and *Hydrocotyle*, and water-weeds such as *Potamogeton*, *Naias*, and *Utricularia* were to be found under the surface. This area merged into a belt of thick *Papyrus* about 20 yards wide which effectually shaded the water.

Text-fig. 1.


A
B
C
D
Grass & Sedge
Water lilies and Hydrocotyle
Papyrus
Water lilies
Ceratophyllum
20 Yards

Here floating and submerged vegetation was scarce. Position B was selected inside the *Papyrus* where the water was about 4 feet deep. Beyond this belt was position C in a zone of water-lilies about 20 yards wide which completely covered the surface of the water, which was from 5 to 6 feet deep. Here also the submerged vegetation was scarce. At the outer edge of this zone was the open water of the lake, the bottom of which, when the depth did not exceed about 15 feet, was carpeted with a dense growth of *Ceratophyllum* and *Potamogeton*. At position D in this open region the water was about 12 feet in depth.

Temperature measurements.

The diurnal maximum and minimum temperatures at the surface and bottom were taken over a period of 5 days in November 1931 at positions B and D—that is to say, inside the *Papyrus* zone and outside the swamp in the open water. The figures obtained each day were very similar, and Table I gives those for one day, which are typical. It will be seen, firstly, that the water reaches

TABLE I.

		Maximum.	Minimum.
		°	°
Position B	Surface	25·0 C.	17·2
	Bottom (4 ft.)	20·8	19·0
Position D	Surface	22·8	18·2
	Bottom (12 ft.)	20·0	18·5
Shade Temperatures, 20. xi. 30		27·1	13·0

a higher temperature inside the swamp than outside, probably because the former position is more shaded from the disturbing effects of winds, and, secondly, that in both places there is complete reversal of the temperature gradient at night. At first sight it may seem surprising that a reversed gradient of 1·8° C. should occur in water only 4 ft. deep. But experiments done in Cambridge after the return of the expedition showed that, when the surface of water in a glass cylinder is cooled by ice, a reversed gradient of more than 2° C. can be produced in a column of water 18″ high.

Alkalinity, pH, and phosphate content.

Measurements of these characteristics of the water at three different dates are recorded in Table II. The small increase of alkalinity at D between November and February, and the decrease in May are probably due to periods of lower and higher rainfall respectively. The decrease of pH from that of the main lake water to that of the edge of the swamp nearest the shore illustrates the effect of the increased intensity of decaying processes inside the swamp, and of greater photosynthesis due to submerged vegetation in the open water.

The absence of any phosphate measurable by the Denigès method, except within a few yards of the shore, was a condition which was found in November 1930 and in February and March 1931, and was verified a number of times. The reason for this condition will be discussed in a paper dealing with the lake itself. In the present connection it will be sufficient to point out that in January

TABLE II.

	22. xi. 30., 10 a.m.			25. ii. 31., 1 p.m.			4. v. 31., 10 a.m.		
	alk.	pH.	P_2O_5.	alk.	pH.	P_2O_5.	alk.	pH.	P_2O_5.
Position A	0·0026 N.	8·3	1·26 mg. p. l.	—	7·4	1·075	—	7·5	0·23
B	—	—	—	—	8·0	nil	—	7·8	0·09
C	—	—	—	—	8·1	nil	—	8·2	0·10
D	0·0028	9·4	nil	0·003	9·3	nil	0·0029	9·0	0·11

and February, when the growth of the submerged vegetation was at a maximum, and the phosphate content of the outer part of the swamp and of the main lake was not detectable, there was always a considerable amount in the shallow water at the edge. In May, after a rainy period had occurred and the submerged vegetation had to a great extent died out and decayed, some phosphate was to be found in all positions, but less than that previously present at the edge. This was probably the result not only of weed decay in the lake, but also of phosphate being washed in from the surrounding land by rain (*cf.* Carter and Beadle, I, p. 244).

Oxygen Content.

It is obvious from Table III that oxygen was abundant in the water at all positions. Outside the swamp at D the oxygen content in the surface-water at mid-day reached 94 per cent. saturation. Inside the swamp it was considerably lower (43 per cent. saturation at B), but still very high compared

TABLE III (6. iii. 31, midday).

		O_2 c.c. per litre.	Total depth of water.
Position A	depth 1″	2·86	6 ins.
B	„ 1″	2·51	4 feet.
C	„ 1″	2·86	5–6 feet.
	„ 18″	1·56	
D	„ 1″	5·60	12 feet.
	„ 7 feet	4·95	

with the figures obtained from the Paraguayan swamps (Carter and Beadle, I, p. 246), and, as the estimation at position C shows, the water at a depth of 18 inches was still well oxygenated. It appears that in these swamps oxygen is not a biologically limiting factor.

Corrections should be applied to Table III to allow for the error due to the presence of sulphide (as described on p. 136). The oxygen content is probably slightly higher than is indicated in the Table.

Remarks on Fauna and Flora.

Pond-net collections were made at positions A, C, and D in March 1931.

The plankton at A was extremely rich and included the following :—

Crustacea (*Cyclops*, *Diaptomus*, Cladocera, and Ostracods).
Oligochaeta (Naididae).
Hirudinea.
Platyhelminthes (*Mesostomum* and *Microstomum*).
Rotifera (colonial and solitary).
Nematoda.
Hydrachnida.
Insecta (Ephemerid larvae).
Protozoa (*Volvox*).
Algae (Chlorophyceae).

At C fewer species were found :—

Crustacea (mostly Cladocera, a few *Cyclops*, *Diaptomus*, and Ostracods).
Insecta (Ephemerid larvae).
Diatomaceae (*Melasira* sp. abundant).

The plankton at D was less abundant than at either A or C, and included :—

Crustacea (Cladocera, *Cyclops*, *Diaptomus*, and Ostracoda).
Hydrachnida.
Rotifera (solitary).
Diatomaceae (*Melosira* sp.).
Algae (Cyanophyceae).

It was quite evident that the swamp supports a greater density of aquatic organisms than does the main lake. This is especially true of the region near the shore, where the great abundance of plankton may perhaps be ascribed in part to the higher content of phosphate and organic food-stuffs in the water.

The lake contains no indigenous fish except the small *Haplochilichthys antinorii*, which was only found in the open waters. But *Tilapia nigra*, which has been recently introduced and is now exceedingly common, was always to be found in great numbers in the swamps. This fish has a truly aquatic respiration.

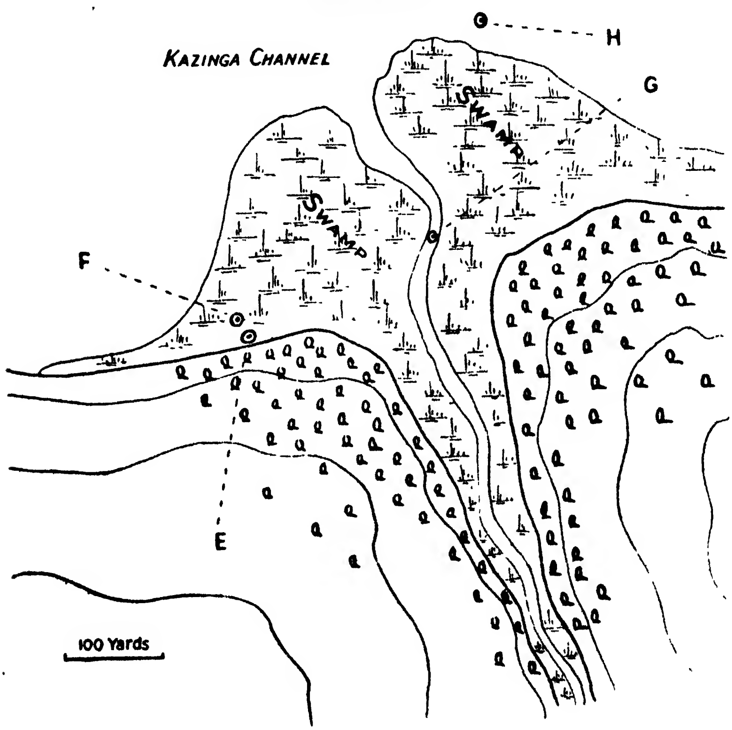
KATUNGURU (0° 10′ S., 30° 0′ E., 3,000 ft. above sea-level). (Pl. 4. Map 2.)

A diagram of the swamps at the mouth of the Chambura River, which flows into the Kazinga Channel ½ mile east of Katunguru in Uganda, is given in

text-fig. 2. The positions selected for observation are marked as E, F, G, and H.

E is in one of a series of open pools about 1 foot deep at the edge of the swamp, which are well shaded by the trees on the bank. F is about 10 yards inside the swamp, which is composed solely of *Papyrus*. The water is almost entirely covered with a carpet of dead and decaying *Papyrus* stems, nearly compact enough to support the weight of a man. In a few places, however, the water is sufficiently uncovered to enable sampling bottles to be inserted. A photograph of a typical *Papyrus* swamp of this neighbourhood is given as text-fig. 3.

TEXT-FIG. 2.



Both the positions are well protected from winds by the surrounding vegetation. Position G is situated in the open course of the river inside the swamp, and H in the open water of the Channel. The Kazinga Channel, in spite of its appearance, does not contain flowing water. It merely connects Lakes Edward and George, which are at the same level.

Observations on these swamps were made in May and June 1931. Readings of shade temperature made on the shores of the channel over a period of 10 days in June and July 1931 show an average maximum of 30° C. and an average minimum of 18·8° C.

Temperature, pH, and Oxygen Content.

From Table IV it can be seen that in the early afternoon in positions E and F there was a large temperature gradient descending from the surface, and this was more marked amongst the *Papyrus* at F than in the pool E. In the early morning this gradient disappeared, the temperature being almost identical at top and bottom. A very slight reversal of the gradient occurred on the morning of 31. v. 31, which was cooler than the preceding morning, but this was small in comparison with the reversal found in the Naivasha swamps.

The pH measurements indicate that, owing no doubt to a greater intensity of processes of decay, the water of the *Papyrus* region (F) was more acid than that of the pool E. The figures showing a reduction of the pH at E from 6·2 to 6·1 between 2·15 p.m. and 7·0 a.m. cannot be taken as trustworthy, since the samples, being collected at different times, could not be compared together after addition of the indicator. Photosynthesis, which a diurnal

TABLE IV.

Date.	Time.	Temperatures, ° C. Air, shade.	E. Top.	E. 1 ft.	F. Top.	F. 1 ft.	O_2 1″ under surface, c.cm. p. l. E.	F.	pH, surface. E.	F.	Alkalinity. E.	F.
29. v. 31.	2.30 p.m.	29·8	26·4	22·5	26·7	21·4	—	—	—	—	0·00075	0·00075
30. v. 31.	7.0 a.m.	20·1	20·3	20·3	20·6	20·7	trace *	nil	—	—	—	—
	2.15 p.m.	29·8	27·5	23·5	26·7	21·6	,,	trace	6·2	5·9	—	—
31. v. 31.	7.0 a.m.	18·9	19·8	20·1	20·5	20·6	,,	,,	6·1	5·9	—	—

lowering of pH would indicate, must, however, have been occurring in the pool E because a small quantity of plant-life was present there (see remarks on fauna and flora).

In view of the absence of photosynthesis in the *Papyrus* region, it is not surprising that its water contained no detectable oxygen within an inch of the surface even in the afternoon, but that the oxygen content of the pool water at E, in spite of the photosynthesis occurring there, should also be undetectable certainly would not be expected. It seems that, owing to the absence of more than a very slight temperature gradient reversal and to the thorough protection from winds afforded by the surrounding vegetation, the extra oxygen produced by photosynthesis must have been removed as a result of the high intensity of organic decomposition. This point will be dealt with more fully in the discussion.

* The minimum amount of O_2 measurable by the Winkler method is about 0·02 c.cm. per litre.

Alkalinity and phosphate content.

The alkalinity of the swamp water at E and F (0·00075 N.) and that of the Chambura River at G (0·00094 N.) was considerably lower than that of the main channel at H (0·00196 N.).

The phosphate content of the two swamp positions (E, 0·21; F, 0·18; G, 0·205 mg. per litre) was higher than that of the channel water (H, 0·11 mg. per litre).

Both these determinations (done on the same day, 27. v. 31) again indicate

TEXT-FIG. 3.

that rain-water running in from the surrounding land, to which the low alkalinity at E, F, and G is presumably due, brings a relatively large amount of phosphate with it.

Remarks on Fauna and Flora.

The phytoplankton of the open channel was so abundant that the water was quite green. A blue-green alga (*Microcystis flos-aquae*) was mainly

responsible for this coloration. The phytoplankton of the pool E was by comparison very scarce, but a few filamentous algae and diatoms were found. The swamp water at F was not entirely devoid of plant-life, but contained only a very small number of diatoms.

Owing to the difficulties of collecting in the swamp, it was impossible to make a comparison of the densities of the zooplankton in the channel with that in the swamp. That of the pool E, however, which included Cladocera, copepods, and ephemerid larvae, was very much more abundant than that of the swamp at F, where only a very few Cladocera and copepods could be found.

The many fish which inhabited the open channel will be recorded elsewhere. Observations were insufficient to establish definitely which species were to be found in the swamps and which were incapable of living in them, but no fish were ever seen at positions E and F, except the air-breathing *Spirobranchus* sp., which was very common, especially at E. Amongst a number of fish with purely aquatic respiration living in the channel was *Tilapia nilotica*, which was never found inside the swamp. In contrast, it will be remembered that *Tilapia nigra* was a common inhabitant of the Naivasha swamp. *Clarias lazera* and *Protopterus aethiopicus*, both air-breathing fish, were very common in the channel water, where they seemed to live in preference to the swamp.

The oligochaete *Alma emini* * was found in great numbers amongst the rotting *Papyrus* stems floating on the swamp surface and in the mud at the edge of the swamp. It presented a most striking similarity both in its appearance and in its habits to the *Drilocrius* sp. found in the Paraguayan swamps (Carter and Beadle, III, pp. 380–5). Without exception, all the peculiarities of behaviour from which it was concluded that the latter was able to breathe atmospheric oxygen (exposure of a dorsal groove at the surface of the water above the mud &c.) were also observed in the behaviour of *Alma emini*.

Kitoma.

About a mile from the Lake George mouth of the Kazinga Channel on the south side is a narrow arm of water, about three-quarters of a mile long and 100 yards wide, completely choked with *Papyrus* swamp except at its mouth. A plan of this area is given in text-fig. 4. The positions selected for observation (J, K, and L) were situated 20 yards outside the swamp and 10 yards and half a mile inside the swamp respectively. This work was done at the beginning of July 1931.

Kitoma is within eight miles of Katunguru and at the same altitude. Both, therefore, are subjected to the same temperature conditions.

The swamp was composed entirely of dense *Papyrus*, and the water of the less dense regions at the outer edge at K was covered by the floating cabbage-like *Pistia*. Position L was in an open pool, well shaded from both sunlight

* I am indebted to Lt.-Col. J. Stephenson, F.R.S., for the identification of this species.

and winds by *Papyrus*, and by trees on the bank. The surface was partly covered by *Lemna*. The water here was quite clear, while that of the channel was green in colour due to blue-green algae.

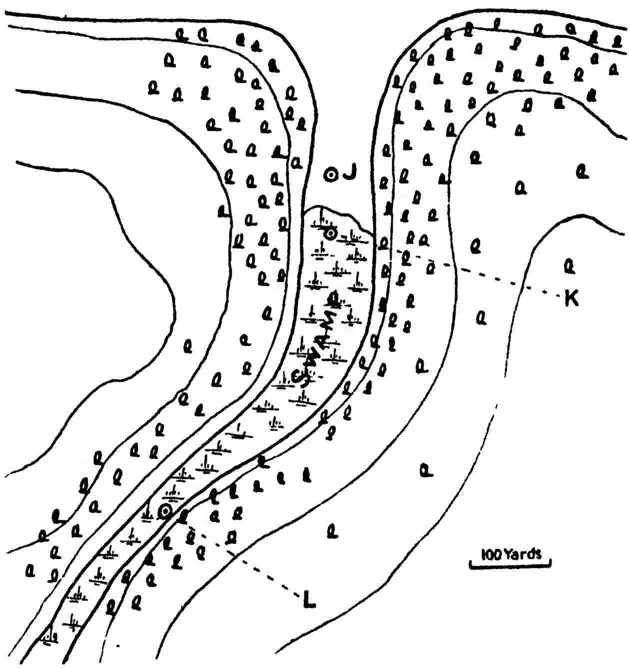
Alkalinity, pH, phosphate, oxygen, and iodine absorption.

These are recorded in Table V. Temperature measurements were not made.

The much greater alkalinity at L can perhaps be explained by the fact that there are at least two very alkaline crater lakes less than two miles inland

TEXT-FIG. 4.

KAZINGA CHANNEL



from this swamp (L. Bagusa 0·23 N. and L. Maseche 0·71 N. alkalinity), and the existence of these lakes suggests that the water of this swamp may gain soda from some subterranean source.

In spite of its higher alkalinity the water at L was considerably more acid (lower pH) than that at J and K. This shows how great must be the intensity of decay in the swamp and of photosynthesis in the channel. The phosphate content of the swamp, however, showed only a small increase over that of the channel.

The differences between the oxygen content of the water at the three positions was very marked. Owing to the great intensity of photosynthesis at J the water at mid-day contained oxygen to the extent of 154 per cent. saturation, while

at L the water was devoid of a measurable amount of oxygen. The relatively high oxygen content at K was no doubt due partly to a certain degree of photosynthesis, and partly to invasion of water from J.

The measurements of iodine absorbed indicate that the sulphide content inside was greater than that outside the swamp. In the present connection, however, the main significance of this is that, though the estimation by the Winkler method showed no oxygen at L, there is no direct evidence against the existence of any amount up to 0·56 c.cm. of oxygen per litre, which is the equivalent of 1 c.cm. of N/100 iodine per 100 c.cm., and which could not, therefore, have been detected by the Winkler method.

TABLE V.

Position.	Alkalinity.	pH.	O_2 c.cm. p. l. 2″ under surface.	c.cm. N/100 I. Absorbed by 100 c.cm.	P_2O_5. Mg. p. l.
J	0·00207 N	9·2	8·6	0·388	0·15
K............	0·00207	8·6	5·0	0·495	—
L	0·00716	6·7	nil	1·000	0·19

It is unfortunate that more work was not done on the question of sulphide content of swamp waters so that generalizations could be made more safely. In this case, however, even if there was as much as 0·56 c.cm. per litre (there may have been less) in the surface-water at L, the oxygen content would still fall a long way below that of the Naivasha swamps, and would be of the same order as that found in the swamps of the Paraguayan Chaco. It would, therefore, perhaps be safe to conclude that, though the oxygen content may be higher than was originally thought, it is still a biologically limiting factor in these two Uganda swamps and in those of the Chaco.

Remarks on fauna and flora.

The plankton of the channel was, as at Katunguru, extremely rich, especially in blue-green algae. That of the swamp at L was entirely devoid of phytoplankton, and appeared to consist only of a few Cladocera and copepods, which were certainly scarcer than in the Katunguru swamp at F.

The oligochaete *Alma emini* was found in the mud at the swamp edge.

DISCUSSION.

From a faunistic point of view the three tropical swamps described in this paper present two quite distinct types. The first (L. Naivasha in Kenya at an altitude of 6,200 feet) supports a large and varied phyto- and zooplankton, the second (Katunguru and Kitoma in Uganda, altitude 3,000 feet), to which type must also belong the swamps of the Paraguayan Chaco in S. America

(altitude less than 100 feet), is relatively very poor in plankton of every kind, both in density and in number of species. So far as the zooplankton is concerned, there appears to be no limiting factor which separates the two types other than the oxygen content of the water. This in the swamps at the higher altitude is abundant (e.g. 1·56–5·6 c.cm. per litre at Naivasha), while in those at the lower altitude it is scarce even in the surface-waters (nil–0·56 c.cm. per litre), and falls below the minimum tension which most aerobic aquatic animals are able to survive under experimental conditions (Carter and Beadle, I, pp. 247–8).

The following factors must be involved in influencing the oxygen content of such waters :—

	Increasing the Oxygen.	*Decreasing the Oxygen.*
Day...	1. Diffusion from the air. 2. Photosynthesis.	1. Absence of wind mixing. 2. Temperature gradient acting against convection. 3. Decay and respiration (increased by high temperature).
Night .	1. Diffusion from the air. 2. Lessening or reversal of temperature gradient and thus more oxygen gained by convection.	1. Absence of wind mixing. 2. Non-reversal of temperature gradient. 3. Photosynthesis stopped. 4. Decay and respiration (but decreased by lower temperature).

In the swamps at the lower altitude it appears that the environment is dominated by those factors which tend to decrease the oxygen content. At higher altitudes this is not the case, and oxygen is abundant in the waters.

The reason for the difference in oxygen content between the two types of swamp is probably to be found in the difference of temperature conditions, which is a necessary consequence of the different altitudes at which the swamps lie. The average temperatures of air and swamp water in the Chaco, Katunguru, and Naivasha have been put together in Table VI.

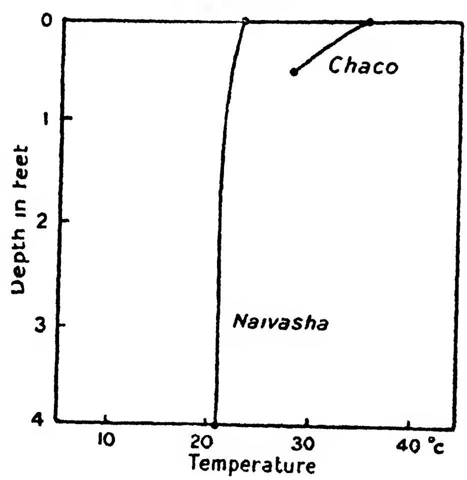
So far as air temperature is concerned, Katunguru is intermediate between the hotter Chaco and the cooler Naivasha. These temperature differences would, in the first place, result in different rates of bacterial decomposition in the waters of different altitudes. It can be found from Table VI that the average top and bottom temperatures of the Chaco water are greater than those of the Naivasha water by 5°–6° C. Assuming the temperature coefficient (Q_{10}) of bacterial decomposition to be in the region of 2·0, it could be said that the rate of decomposition in waters at the lower altitude of the Chaco is about 1·5 times as great as the rate of decomposition occurring in the Naivasha waters at a higher altitude. It would thus be reasonable to expect that in this way the higher temperature of the lower altitude is responsible for the lower oxygen content of the water as compared with waters at a higher altitude where they are subjected to lower temperatures.

TABLE VI.

				Air temperatures, °C.			Water temperatures, °C.					
							Top.		Bottom.		Difference.	
Swamp.	Depth.	Zooplankton.	Period of observation.	av. max.	av. min.	Differences. av. max.–av. min.	av. max.	av. min.	av. max.	av. min.	Top–bottom. max.	Top–bottom. min.
Paraguayan Chaco (<100 feet).	6 ins.	scarce.	15 days, Nov. 1926.	35·0	23·0	12·0	35·0	22·0	28·0	22·0	7·0	0
Katunguru (3,000 feet).	1 foot	scarce.	2 days, May 1931.	30·0	18·8	11·2	27·0	20·05	23·0	20·2	4·0	−0·15
Naivasha (6,200 feet).	4 feet	abundant.	5 days, Nov. 1930.	25·5	9·6	15·9	23·2	18·1	20·9	19·5	2·3	−1·4

It is also clear from Table VI that the difference between the average maximum and average minimum air temperatures in the Chaco (12·0° C., daily mean temp. 29° C.), and at Katunguru (11·2° C., daily mean temp. 24·4° C.) is less than that at Naivasha (15·9° C., daily mean temp. 18° C.). This would mean that the surface-temperature of the water at Naivasha would be lowered to a greater extent at night, and reversal of the temperature gradient would thereby be more likely to occur than in the case of the Chaco or Katunguru. That this is the actual state of affairs is shown clearly by the differences between the surface and bottom minima. The reverse gradient, which is very marked in the Naivasha swamps, does not occur in the Chaco waters except under unusual climatic conditions in rare periods of cooler weather. A reversal of temperature gradient at night would result in oxygenation of the water from the air by convection currents which could not happen if, as in the case of the Chaco swamps, there is no temperature gradient reversal.

TEXT-FIG. 5.



There is probably a second reason for the temperature gradient reversal at the higher and for none at the lower altitude. The temperature gradient at mid-day in the water of the latter is very much steeper than that of the former. This is shown in text-fig. 5, in which the surface and bottom maximum temperatures in the Chaco and at Naivasha are plotted against depth. What is the explanation of the occurrence of a much steeper mid-day temperature gradient in warmer waters at a lower altitude than in cooler waters at a higher altitude ? The answer may be found in the fact that, although the maximum temperatures of the surface-waters in the three places (Table VI) are widely divergent, the differences between the maximum temperatures at the bottom are smaller, and the bottom minimum temperatures approach one another still more closely (22·0, 20·2, and 19°·5 C.). It appears, in fact, as though

the bottom mud were acting to a certain extent as a thermostat in restraining the temperature changes of the bottom water, in spite of very different degrees of surface-heating during the day at the different altitudes. In other words, the surface of the water in the hotter climate is warmed up to a greater extent than is that in the cooler climate, the temperature of the bottom water, however, does not rise proportionately.*

The result is a much steeper temperature gradient at mid-day in the warmer place at the lower altitude. This being so, it is evident that, even with the same range of air temperature, the surface and bottom temperatures in the cooler and higher place would require less time to become equalized at night, and thus to cause a temperature gradient reversal, than would be the case in the warmer and lower place.

An obvious criticism of the conclusions which have been drawn from the figures given in Table VI is that the total depth of the water is different in each case. In the water of the Chaco swamp a lower oxygen content would be expected, since there was only a small quantity of water (6 inches) subjected to the decomposition of the mud. In the Naivasha swamp the water was 4 feet deep, and for this reason alone would be deprived of less oxygen per unit volume than would the shallower water of the Chaco. Can we then justify the conclusion from the figures in Table VI, which were obtained from waters of different depths, that the occurrence or non-occurrence of a temperature gradient reversal is largely responsible for the presence or absence of oxygen in the water?

This criticism can be met in two ways. Firstly, oxygen measurements were made in the deeper parts of the Chaco swamps where the water was 3 feet deep. The results, which were not published in detail, showed that even in water of this depth the oxygen content of the surface-layers did not exceed 0·18 c.cm. per litre under normal conditions, and at a depth of 1 foot was of the order of 0·02 c.cm. per litre, both figures being subject to correction for sulphides. These figures are therefore comparable with those obtained from water 4 feet deep at Naivasha, where the oxygen content of the surface-water was as high as 2·5 c.cm. per litre.

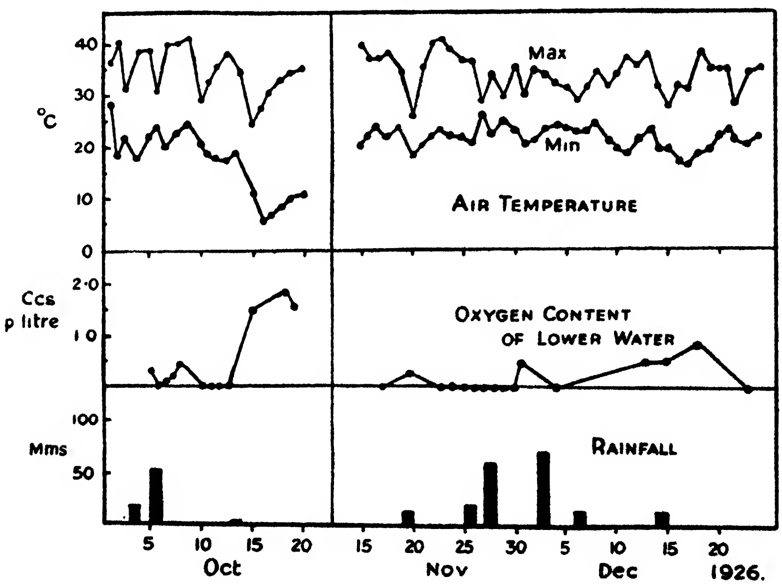
Secondly, it was found that on a few occasions oxygen was detectable in the lower layers of Chaco swamp water, where it was normally undetectable. This is shown by text-fig. 6 (extracted from Carter and Beadle, I). The four periods in which an increase of oxygen content of the lower water took place (with maxima on October 18th, November 20th, December 1st, and December 18th) corresponded to falls in the minimum air temperature. The greatest increases of oxygen content, which occurred from October 13th to 18th and from

* In this connection it is of interest to note that in the swamps of the Paraguayan Chaco the temperature of the bottom mud at a depth of 6 inches was remarkably constant both from one day to the next and from morning to afternoon in spite of great changes in the temperature of the surface-water. On no occasion was there found a diurnal temperature change in the mud of more than 1° C. (Carter and Beadle, I, p. 225).

December 5th to 23rd, were contemporary with a high maximum in addition to a low minimum air temperature. It will be seen from the rainfall records that these two periods were particularly dry, and it was generally found that the rainfall had little effect on the oxygen content of the lower water. Thus a fall in the minimum air temperature, by causing a reversal of the temperature gradient at night, was primarily responsible for the rise in the oxygen content of the water. This was particularly effective when the difference between the maximum and minimum air temperatures was relatively high and, in fact, of the same order as that found at the higher altitude of Lake Naivasha.

It would appear from these two examples that the occurrence or non-occurrence of convection currents plays the major part in determining the presence or absence of oxygen in the water.

TEXT-FIG. 6.



It seems then that the difference of temperature conditions only, by determining both the rate of bacterial decomposition and the occurrence of convection currents, is ultimately responsible for the lack of oxygen in the waters at a low altitude and for its abundance in those at a high altitude.

There is no obvious reason why the swamps at a higher altitude should be able to support a much richer phytoplankton than those at a lower altitude, since, of all the factors investigated, the temperature conditions and the oxygen content only appear to be consistently different in the waters of these two environments. The waters of the swamps at low altitudes contain as much bicarbonate and phosphate as do those of the open lakes with which they are

connected and in which phytoplankton is abundant. It therefore seems probable that the water contains sufficient quantity of dissolved substances necessary for plant-growth. It is perhaps possible that, owing to the higher temperature of the swamp water at the lower altitude, a greater quantity of some substances toxic to phytoplankton are produced as a result of a higher rate of bacterial decomposition than in swamps at a higher altitude. This question, however, needs further investigation.

In considering the distribution and adaptations of the fauna, it must be remembered that the three African swamps discussed here were in open communication with the well-oxygenated water of open and deep lakes. This was not the case in the Chaco. It is, therefore, not unexpected that the number of adaptations to aerial respiration was smaller in the African swamps. It may seem surprising that the commonest air-breathing fish of these African waters (*Protopterus* and *Clarias*) were found mostly in the open lake water. It is reasonable to assume that the aerial respiratory organs of these fish were not evolved in such an environment. Perhaps the geological history of the country may give us a clue to the manner in which air-breathing has been evolved in some fish of these swamps. The Great Lakes of Central Africa have arisen, since Mesozoic times, as a result of the formation of the two Great Rift Valleys in the floor of which they all lie with the exception of Lake Victoria, and the depression which the latter occupies was formed by the same earth-movements which gave rise to the Rift Valleys (Gregory, 1921, p. 359; Wayland, 1931, p. 40). Before the uprising of the earth's surface, which preceded the formation of these valleys, the waters of Central Africa were in all probability slow-flowing rivers and shallow lakes. These conditions would have favoured the development of swamps, which would, therefore, have covered far greater areas than they do now, and would not have been connected with large open lakes. In such an environment it is conceivable that the air-breathing organs of these fish developed.

It is not intended to suggest any particular geological age during which the aerial respiratory organs of African fish were evolved. But we can say with reasonable certainty that these air-breathing fish have not always existed in an environment such as they inhabit to-day, where there is free access to well-oxygenated waters. Before the formation of the Rift Valleys they probably lived in 'closed' swamps, where their aerial respiratory organs would have been of survival value.

I am much indebted to Dr. G. S. Carter and to Mr. J. T. Saunders for assistance during the course of this work.

Summary.

(1) The conclusion gained from work in Central South America (Carter and Beadle, I, 1930) that swamps under tropical climatic conditions support a comparatively poor fauna and flora of truly aquatic forms is confirmed by a study of certain East African swamps.

(2) The scarcity of the aquatic fauna can only be attributed (as in the case of the South American swamps) to the very low oxygen content of the water, which is also a characteristic of the tropical African swamps investigated.

(3) No satisfactory explanation has been found for the scarcity of the aquatic flora in swamps subjected to a tropical climate in both Central South America and in East Africa, and for its abundance in similar swamps in a more temperate climate such as that of Lake Naivasha in Kenya.

(4) The errors in the determinations of oxygen content by the Winkler method due to the presence of reducing substances such as sulphides in the water (for which no allowance was made in the work on South American swamps) are not sufficiently great to affect the main conclusion that lack of oxygen is a biologically limiting factor in these waters.

(5) This conclusion is further supported by a study of the conditions existing in swamps bordering Lake Naivasha in Kenya, which, though close to the Equator, lie at an altitude of 6,200 feet, and are thus not subjected to truly tropical climatic conditions. In these swamps the fauna and flora are abundant, and the water contains a comparatively large amount of oxygen.

(6) The reason for the low oxygen content of tropical swamp waters at low altitudes and for the high oxygen content of those at high altitudes is to be found solely in the difference of temperature conditions consequent upon a difference of altitude.

(7) The oxygen content of the water is affected by the temperature conditions in two ways :—

1. The higher temperature at the lower altitude causes an increase in the rate of bacterial decomposition, and a greater amount of oxygen is thereby removed from the water than is the case at the higher altitude where the temperature is lower.
2. Under normal conditions the mid-day temperature gradient in the water of swamps in the hotter climate is relatively steep, and the minimum air temperature is not sufficiently low to cause a reversal of the gradient at night. The water is consequently not oxygenated by convection currents. In swamps in the cooler climate the mid-day temperature gradient is considerably less steep and the minimum air temperature is low enough to effect a reversal of the gradient at night, with the result that the water becomes oxygenated by convection currents.

(8) Most of the swamps of Central and East Africa are in open communication with the well-oxygenated waters of open lakes and rivers. Reasons are given for the assumption that this was not always so, and that at any rate before the formation of the Rift Valleys 'closed' swamps, such as now exist in Central South America, were more general. Under such conditions the aerial respiratory organs of certain African fish, which are now found in well-oxygenated waters, would have been of survival value.

References.

ALSTERBERG, G. Die Winkler'sche Bestimmungsmethode für in Wasser gelösten, elementaren Sauerstoff sowie ihre Anwendung bei Anwesenheit oxydierbarer Substanzen. Biochem. Zeitschr. clxx, 1926.

CARTER, G. S., & BEADLE, L. C. The Fauna of the Swamps of the Paraguan Chaco in relation to its Environment.

I. Physico-chemical Nature of the Environment. Journ. Linn. Soc., Zool. vol. xxxvii, no. 251, 1930.

II. Respiratory Adaptations in the Fishes. *Ibid.* no. 252, 1931.

III. Respiratory Adaptations in the Oligochaeta. *Ibid.* no. 253, 1931.

GREGORY, J. W. The Rift Valleys and Geology of East Africa. London, 1921.

RUTTNER, F. Hydrographische und hydrochemische Beobachtungen auf Java, Sumatra und Bali. Archiv für Hydrobiol., Suppl. Bd. viii, Heft 2, 1931.

THRESH, J. C., & BEALE, J. F. The Examination of Waters and Water Supplies. London, 1925.

WAYLAND, F. J. Summary of Progress of the Geological Survey of Uganda for the Years 1919–1929. Entebbe, Uganda, 1931.

Scientific results of the Cambridge Expedition to the East African Lakes, 1930–1.—4. The waters of some East African Lakes in relation to their fauna and flora. By L. C. Beadle. (Communicated by Dr. E. B. Worthington, F.L.S.)

(With 7 Text-figures)

Contents.

	Page
Introduction	158
General description of the East African Lakes	159
Methods	162
Lake Naivasha	166
General	166
Water supply	167
The subterranean outlet	167
Large aquatic vegetation	169
Plankton	170
Composition of the surface-waters	171
Analyses of samples from different depths	173
Penetration of light for photosynthesis	175
Changes during period of observation (summary)	176
Naivasha Crater Lake	177
Lake Baringo	178
General	178
Water supply and subterranean outlet	178
Large aquatic vegetation	179
Water temperature	180
Plankton	180
Water analyses	181
Changes since 1929	182
Penetration of light effective for photosynthesis	182
Lake Hannington	183
Lake Rudolf	184
General	184
Water supply and former lake-levels	185
Large aquatic vegetation	186
The water of the open lake	186
The effects of increasing alkalinity on the plankton	188
The Crater Lakes of Central Island	190
Lakes Edward and George	192
General	192
Water supply and drainage	193
Large aquatic vegetation	194
Surface-waters of Lakes Edward and George	194
The effect of swamps on phosphate supply	194
The Kazinga Channel–Lake Edward junction	196
The deep water of Lake Edward	199

	Page
Lakes Bagusa and Maseche	200
Lake Kikorongo	201
Discussion	203
Effects of increased alkalinity on composition of water	203
Evidence for biologically limiting factors	204
Layering of the lake waters	208
Summary	209
References	210

Introduction.

The inter-relations of the aquatic fauna and flora with the chemical and physical conditions which constitute their environment have been studied by a large number of workers. Attention has, however, been confined mainly to the sea and to temperate fresh waters. Though much work has been done by biologists on the fauna and flora of tropical fresh waters, whose distribution is now fairly well known, a study of the constitution of the water as it affects the nature, abundance, and habits of the fauna and flora has until recently been neglected.

An expedition under Thienemann has lately made a thorough investigation of the lakes of Java, Sumatra, and Bali, and detailed work was done by Ruttner (1931) on the constitution of the waters. As a result, it was found that the classification of lake types derived from a study of temperate waters would not apply to tropical lakes (Thienemann, 1931).

In East Africa work of this nature has been done by Miss Jenkin (1932 *a* & *b*) on Lakes Naivasha, Nakuru, Elmenteita, and Baringo, in Kenya. The great differences in alkalinity of the waters of these four lakes (0·004 N. in Naivasha to 0·26 N. in Nakuru) were chiefly responsible for the great differences in the type and abundance of the fauna and flora, especially of the phytoplankton. Measurements of temperature, alkalinity, and pH of the waters of Lakes Victoria, Kioga, and Albert were made by Worthington (1930) in 1928.

The chemical and physical condition of the waters of some East African Lakes in relation to their fauna and flora is to form the subject of this paper. This work was done during the course of the 'Cambridge Expedition to the East African Lakes' in 1930–1 (led by Dr. E. B. Worthington). A general account of the work and itinerary of the expedition is published in conjunction with this paper, together with the maps and list of observation stations to which reference will continually be made (Worthington, 1932 *b*). A short general discussion of these lakes and their surroundings will afford sufficient background for the data recorded in this paper.

For advice and assistance during our stay in Africa I am much indebted to Dr. W. S. Martin, Government Chemist, and to Dr. G. Griffith, of the Agricultural Laboratory, Kampala, Uganda. I also received valuable assistance from Dr. Fox, Government Chemist at Nairobi, Kenya. Mr. R. E. Dent of the Kenya Game Department accompanied the expedition for the first

two months, and lent us his house on L. Naivasha, from which the work on that lake was done; and his extensive knowledge of the country, and particularly of L. Naivasha, was of great value to us. Before leaving England, I was supplied by Miss P. M. Jenkin with valuable information concerning the lakes of the Naivasha district collected by her during her visit in 1929. For advice and assistance on methods, both before and during the course of the expedition, I am greatly indebted to Mr. J. T. Saunders of Cambridge.

The Government Chemist in London kindly consented, at the request of the Colonial Office, to make total analyses of water samples from some of the larger lakes, the results of which are published in Table XV.

For the identification of the larger aquatic vegetation we are indebted to Mr. Ramsbottom of the British Museum, and of the planktonic algae to Miss Rich of East London College.

General description of the East African Lakes.

With the exception of Lakes Victoria and Kioga, the large lakes of East Africa lie within the two Great Rift valleys. The Eastern Rift extends from Lake Nyassa northward through Tanganyika Territory, Kenya, and Abyssinia, and is considered to be continuous with the valley which now contains the Red Sea, and with the Jordan valley in Palestine. Among the lakes which now lie on the floor of this Rift are Lakes Nyassa, Magadi, Naivasha, Nakuru, Elmenteita, Baringo, Hannington, and Rudolf. The Western Rift is a smaller branch of the above, and extends from Lake Nyassa north-west to Lake Tanganyika, and thence northward as far as Lake Albert, and contains in addition Lakes Kivu, Edward, and George. Lakes Victoria and Kioga are situated in a basin between these two valleys (see Map 3).

The earth-movements which preceded the formation of the Rift Valleys probably began in the early Mesozoic, and comprised an uprising of a belt of land extending in a N–S direction throughout Eastern Africa. This was accompanied by volcanic activity, and vast quantities of lava were thrown to the surface. At some period towards the end of the Mesozoic a series of parallel faults began to occur which now mark the sides or escarpments of the Rift Valleys. The intervening land began to sink relatively to the surrounding country, and became the floor of the valley. This process of faulting and subsidence probably continued until recent times, and was accompanied by volcanic activity, the results of which may now be seen in the numerous craters on the valley floor. A few of these are still in the last stages of eruption (Gregory, 1921, pp. 357–66).

Previously to this faulting the land now situated between the Eastern Rift and Lake Victoria was sufficiently high to form a watershed from which rivers flowed westwards into the Congo basin. The subsequent movements, which gave rise to the Rift valley faults, resulted in the subsidence of the Lake Victoria basin, and the flow of the portions of these rivers between this basin and the western Rift was reversed, so that they began to flow eastward to swell

the waters of the newly formed Lakes Victoria and Kioga (Wayland, 1931, p. 44).

The Rift Valleys themselves formed catchment-areas for water, and lakes were formed within them. Since early Pleistocene times there have been great fluctuations in the climate of this part of Africa, and the waters of these lakes have risen and fallen a number of times in response to alternate periods of high and low rainfall. From a study of old lake beaches in the Nakuru–Elmenteita and Naivasha basins, Leakey has concluded that, since a very long pluvial period in the early Pleistocene, when the Kamasian beds were laid down, there was a dry period during which much faulting took place through these beds, and the present lake basins were formed. Subsequent to this, there were four periods of high rainfall, when the lake levels rose, alternating with periods of relatively low rainfall, when the levels fell. The second of these interpluvial periods (between the upper Gamblian and Makalian wet phases) was one of intense aridity, and the lakes were completely dried up. At the present moment a dry period, following on the last (Nakuran) wet phase, is in progress. The level of L. Nakuru is 750 feet and that of L. Naivasha 380 feet below their highest known level (in the Lower Gamblian pluvial period) (Leakey, 1931 *a*, p. 497, and *b*, pp. 6–18). Investigations by Wayland on the fossil beds of Lake Albert have, to a large extent, supported Leakey's conclusions with regard to these climatic fluctuations (Wayland, 1931, pp. 38–9).

A characteristic of the lavas, which were discharged throughout this long volcanic period accompanying the formation of the Rift Valleys, is their richness in soda and poorness in lime (Gregory, 1921, p. 358). Large quantities of sodium carbonate, which is extremely soluble in water, have therefore found their way into the lakes. The evaporation and reduction in volume, which has occurred to a greater or lesser extent with all these lakes during the present relatively dry period, has resulted in concentration of the soda in the water. All the lakes within the Rift Valleys are, in fact, definitely alkaline, their alkalinity being mainly due to sodium carbonate, and not to any extent to calcium carbonate as is the case with most natural waters. Such a condition is rare, but has been found in the Lahontan Lakes of Nevada, in the United States (Clark, 1924, p. 159).

For various reasons, to be discussed later, the alkalinity varies greatly between different lakes. The lowest figure recorded during this expedition was 0·002 Normal in Lake George, and the highest was 0·71 Normal in Lake Maseche, a small crater lake within one mile of Lake George. This illustrates the fact that many of the lakes may derive their soda not only directly from rivers, which dissolve it from the soda-bearing lavas of the surrounding country, but also from subterranean springs. This is definitely the case with Lake Baringo, where water of a higher alkalinity than that of the lake is flowing into the lake from hot springs on Ol Kokwa island.

Besides the larger lakes, whose basins were formed by the subsidence of the Rift Valley floor, there are a number of small crater lakes. These were formed by the collection of water within the rim of small volcanic craters. They are very common, particularly in the western Rift in the neighbourhood of Lake George, where there are two groups, one north and the other south of the lake, each comprising about 25 lakes within an area of 100 square miles. They are usually circular and not more than a quarter to half a mile in diameter.

It might be expected that a study of a series of lakes of varying alkalinity would show an interesting series of types of fauna and flora, and Miss Jenkin's work on the lakes of the Naivasha region has shown this to be the case (Jenkin, 1932 *a*, pp. 546–50). In the first place, it is probable that a certain concentration of sodium carbonate may be reached, which would render the water toxic to certain animals and plants, owing either directly to the high pH, or to the resulting high osmotic pressure, or to both. Secondly, an increase of alkalinity would mean an increase of available CO_2 for plant-growth, and a consequent increase in the amount of phytoplankton would be expected for this reason alone. This would in turn affect the nature and abundance of the animals feeding on it. A change of alkalinity may also produce biological effects by virtue of the resulting change in concentration of certain kations in solution, such as calcium and magnesium. These would both tend to be thrown out of solution with an increase of alkalinity. There is also the interesting possibility that some organisms may have adapted themselves, during the period of evaporation of the waters, to a high alkalinity and salinity, the effects of which may be marked by changes in their physiological or structural make up, and that a comparison between the same species taken from waters of different alkalinities may show these changes.

The fish of these lakes, which are described elsewhere (Worthington, 1932 *c*), are discussed in this paper only in such cases in which they are probably affected directly by changes in the composition of the water.

The lakes investigated were also at widely different altitudes, since the floor of the Eastern Rift valley, where it cuts through the highlands of Kenya, attains an altitude of over 6,000 feet at Naivasha, and further north at Lake Rudolf it has sunk to little over 1,000 feet. Consequently, though all these lakes lie well within the tropics, they are subjected to very different climatic and particularly temperature conditions. The effect of different temperature conditions at different altitudes on the bionomics of swamps is discussed in another paper (Beadle, 1932). As the meteorological figures show (Table I), Lake Naivasha cannot be considered as being subjected to truly tropical conditions, whereas the climate of Lake Rudolf is definitely tropical. The climatic conditions at Lakes Baringo and Edward, at an altitude of about 3,000 feet, are intermediate.

Average figures calculated from the meteorological data are given in Table I.

The following are the climatic changes which occur in the course of a typical year in the Kenya highlands :—

1. November to December.	'Short rains.'
2. December to February. .	Periods of hot dry weather and high winds in the Rift Valley.
3. March to April	'Long rains.'
4. May to September......	Dry, relatively cool and calm period.

There have apparently been wide deviations in the months in which these periods have occurred and in their duration since records have been taken. But the above gives a rough impression of the course of events.

METHODS.

The conditions experienced on the shores of these lakes were never ideal for laboratory work, which was done either in the back of a lorry, a packing-case serving as a bench, in a hut thatched with palm leaves or grass, in a tent, or in the open air. The high temperatures, winds, and dust, to which one was always exposed even under these improvised shelters, particularly on Lakes Baringo and Rudolf, made accurate chemical work difficult. Metal boxes designed by Miss Jenkin for carrying the glassware and chemicals were found to be indispensable. Moving about from place to place necessitated frequent packing and unpacking of apparatus, and the boxes were exposed to much shaking, dust, and water without harm to their contents. A copper still and primus stove were used for making the distilled water necessary for standard solutions, and for rinsing pipettes and burettes used in chemical determinations. Weighed chemicals were taken in sealed glass tubes.

Meteorological observations.

Readings of maximum and minimum air temperatures, of wet and dry bulb temperatures, and of barometric pressure were made daily on the shore of each of the lakes visited. These are recorded as average figures in Table I.

Water temperature measurements.

The reversing thermometers used for the open lake waters, and one hand-thermometer were standardized by the National Physical Laboratory. From the latter were standardized some maximum and minimum thermometers for use in shallow waters.

Collection of water samples.

A closing water-bottle and winch were employed for collecting samples from below the surface. Samples sent to England for further analysis were sealed in 'Winchester' and 1 pint beer-bottles.

Chemical determinations.

(i) *Alkalinity.*—10 c.cm. of the samples were titrated against sulphuric acid (standardized against a sodium carbonate solution of known strength),

TABLE I.

Meteorological observations.

Place.	Dates.	°C. shade air temperatures.		Humidity.		Barometer (inches).	
		Av. max.	Av. min.	Av. dawn hum., per cent.	Av. mdy. hum., per cent.	Av. dawn.	Av. mdy.
Naivasha (6,200 ft.)	Nov. 20–26, 1930.	25·4	9·6	96·5	82·5	23·44	23·27
Naivasha	Feb. 24–Mar. 6, 1931.	26·9	11·7	—	63·0	23·23	23·08
Baringo (3,150 ft.)	Dec. 3–9, 1930.	32·6	20·3	75·8	42·7	26·20	26·04
Baringo	Jan. 25 to Feb. 1, 1931.	35·5	21·6	66·8	29·2	26·11	25·91
Rudolf (1,250 ft.)	Dec. 25 to Jan 11, 1930–1.	39·2	24·7	72·5	48·4	28·20	28·15
Rudolf	Mar. 20 to April 11, 1931.	39·7	27·0	74·0	45·1	28 15	27·96
Cent. Is., Rudolf	April 2–5, 1931.	41·8	28·8	—	—	—	—
Kazinga, L. Edward (3,000 ft.)	June 9–15, 1931.	30·2	19·0	92·4	60·5	26·16	26·05
Kitoma, L. George (3,000 ft.)	July 16–25, 1931.	29·5	17·0	97·2	60·1	26·34	26·21

using methyl orange as indicator. The end-point was determined by comparing the colour with that of the same volume of unneutralized sample containing the same quantity of indicator. In the case of the most alkaline lakes the samples had to be diluted before the determinations.

(ii) *Hydrogen-ion concentration.*—Few of the waters investigated gave a pH below 9·0. When this was the case (e.g. Lake Naivasha) the necessary sulphon-phthalein indicator was added to the sample, and the colour was compared with Clark's colour chart (Clark, 1928 *b*). The pH values obtained from the colour chart were corrected for salt error on the assumption that the chart colours correspond to borax-boric acid buffers.

When the pH was above 9·0 and below 10·3, as was found with the majority of the lakes visited, it was roughly measured by the phenol-phthalein one-colour method (Clark, 1928 *a*, p. 126). Some waters were even more alkaline, and no direct method was available for measuring the pH.

(iii) *Carbon dioxide content.*—Total carbon dioxide was calculated from the alkalinity and pH (Saunders, 1923). Diurnal changes in carbon dioxide content due to photosynthesis could only be calculated in this way in the less alkaline waters. Since no accurate method was available for the measurement of pH changes in the more alkaline waters, the diurnal changes of CO_2 content were calculated from titrations with standard acid to the phenol-phthalein and methyl orange end-points.

(iv) *Oxygen content.*—This was estimated by the Winkler method (Winkler, 1888). Except in the case of Lakes Edward and George no allowance was made for errors due to reducing substances in the water. So far as swamp waters are concerned, this question is discussed fully elsewhere (Beadle, 1932, p. 147). The possible maximum error due to these substances in the open waters of Lake Edward was equivalent to 0·88 c.cm. of oxygen per litre (at 50 m.), and to 0·18 c.cm. per litre in Lake George (at the surface). The water at a depth of 50 m. in Lake Edward contained a large quantity of free H_2S which was not present in the waters of any other lake investigated. The errors in the oxygen determinations due to reducing substances in the open waters of the other large lakes would therefore not amount to as much as ·88 c.cm. per litre, but would probably be of the order of 0·18 c.cm. per litre, as was found for the waters of Lake George. This error is of small significance in view of the comparatively large amount of oxygen found at all depths in the other lakes (Naivasha, Baringo, and Rudolf).

(v) *Amount of Iodine absorbed.*—This was estimated as an indication of the quantity of sulphide and other reducing substances present in the water. The method is described fully in connection with the work on swamps (Beadle, 1932, p. 136).

(vi) *Phosphate content.*—The phospho-molybdate method of Denigès as modified by Atkins (1932) was employed. No obvious difficulties arose due to coloration of the water except in the case of Lakes Baringo and George, when the comparator method for matching the colours was used (Carter and Beadle, I, 1930, p. 219).

100 c.cm. Nessler tubes were used for comparing the colours produced in the samples and standard. The surface-waters of Lake Naivasha in November 1930 and February 1931 contained so little phosphate that no difference in colour could be detected when two tubes of the lake water were compared, to one of which the necessary reagents had been added. But the method, as here employed, was probably not sensitive to less than 0·01 mg. of P_2O_5 per litre.

(vii) *Silicate content.*—The molybdate method of Diénert and Wandenbulcke, as described by Thresh and Beale (1925, p. 347), was used.* When estimating silicate in the most alkaline waters care had to be taken that sufficient sulphuric acid was added to render the sample completely acid, otherwise the yellow colour would not develop. After adding ammonium molybdate and sulphuric acid to samples taken from below 50 m. in Lake Edward a green colour developed, and the attempt to estimate the silicate was abandoned. It was later discovered that this was due to the reducing action of the H_2S present, and could have been obviated by previous oxidation with potassium permanganate (Thresh and Beale, 1925, p. 347).

(viii) *Electrical conductivity.*—Determinations of this were made at Cambridge on water samples brought home after the expedition, as an indication of the quantity of total dissolved salts.

Penetration of light effective for photosynthesis.

Experiments to determine the depth at which photosynthesis ceased and at which the light intensity was at an optimum were done on Lakes Naivasha and Baringo. The method used was based on that employed by Marshall and Orr (1928, p. 323) in the Clyde Sea area.

A buoy was anchored in the open water, and pairs of Winkler bottles in wire cages were attached to the cable at different depths. All the bottles contained as far as possible the same quantity of plant-material. One of each pair of bottles was covered with thick cloth to exclude light, the other was uncovered. After a given time, the bottles were brought up, and the oxygen content of each was determined. The oxygen consumed in the covered bottles represents the rate of respiration of the plants.

If x c.cm. per litre = final O_2 content of covered bottle, and y c.cm per litre = final O_2 content of uncovered bottle, then the O_2 produced by photosynthesis in a given time in the uncovered bottle $= y - x$ c.cm. per litre.

Determination of density of phytoplankton.

The net used for collecting the plankton for this purpose was of fine mesh (65 per cm.). In lakes which are sufficiently deep (5 metres and over) it was possible to take vertical hauls. In shallower lakes horizontal surface-hauls were made from the boat travelling at a calculated slow speed for a given time.

* In preparing the standard it was assumed that 36·9 mg. of picric acid are equivalent to 50 mg. SiO_2.

A calculation of the number of a given species per litre was made from an average of five figures, obtained by counting the numbers in the view of the microscope. 1 c.cm. of the sample (diluted if necessary) was placed in a shallow cell between the slides made to hold that quantity, and viewed under the microscope. The area of the view and the surface-area of the cell being known, it was possible to find the total number per litre from the amount of water which had passed through the net. This method is obviously subject to error, but it was sufficiently accurate to illustrate the very great difference between the planktons of the lakes investigated. The results are expressed to the nearest 10 per litre.

No attempt was made to count separately species of alga which were present in small numbers. It was only intended to make a rough estimate of the nature and abundance of the phytoplankton. A full list of species found will be published in due course.

[The unit taken for the alga *Microcystis* was a sphere of diameter about 60 μ, and in the case of *Melosira*, *Phormidium*, *Hormidium*, a filament in length about 100 μ.]

Owing to the daily vertical migrations of the zooplankton, no attempt was made to determine its absolute density, but a list of the genera found, together with rough notes on their relative abundance, is given in the tables.

Two visits at most were paid to each lake. The estimations of the nature of the plankton are, therefore, not necessarily a true indication of the conditions at other times of year. But the changes which were found to occur between one visit and another suggested that the plankton of each lake varied only within certain limits.

LAKE NAIVASHA (0° 45′ S., 36° 24′ E.; altitude 6,200 feet; surface-area 70 sq. miles).

General.

This lake, situated in the heart of the Kenya highlands, has become of recent years a pleasure resort, and its fish-production is of ever-increasing importance to the white settlers of the district. The Rift Valley is here relatively narrow (about 20 miles between the escarpments). A plan of the lake and of its immediate surroundings is given in Map 4. The stations at which observations were made are indicated by numbers on this map. It will be seen that, with the exception of a depression within the curve of Crescent Island, where the depth is about 20 metres (Station 30), the main lake is nowhere more than 10 metres deep. Crescent Island is the remnant of the partially submerged rim of a volcanic crater. This rim has presumably to a great extent formed a barrier against water currents from the main lake, and sediments have been, therefore, more excluded from the crater than from elsewhere. In the S.W. corner is a bay (Station 38) which is nearly cut off from the main lake. The water here is of a maximum depth of 13 metres, its composition was slightly

different from that of the lake, and it supported a very different type of plankton.

Observations and collections were made in November 1930 and in February and May 1931. Average figures calculated from the meteorological data obtained in November and February are given in Table I. Although a certain amount of wind was experienced in November 1930, the period of high winds did not properly begin until the end of January 1931, and the second series of observations (in February) were taken during a typical windy period.

Water supply.

There are only two permanent streams flowing into the lake—the Malewa and Gilgil. The former receives water from a very large area including all the western slopes of the Aberdare Mts. The latter drains a smaller area of high land due north of the lake, and the hills above Gilgil. It is a curious fact that there is no stream flowing from the western escarpment into the lake. There is, however, a remarkable cave about 1 mile from the west shore, which has now become famous as the cave of Rider Haggard's 'Alan Quartermain.' In the inaccessible depths of this cave there is undoubtedly a considerable stream of flowing water, which can be heard and which produces air currents. Mr. Fuchs (geologist to the Expedition) visited the cave in April 1931, and concluded that, in all probability, the water was flowing from the escarpment into the lake.

The subterranean outlet.

Lake Naivasha has no surface-outlet. It is, therefore, surprising that the water is fresh compared with that of the other Rift Valley lakes, most of which are closed drainage systems (e.g. Lakes Elmenteita, Nakuru, and Rudolf). The alkalinity of the Naivasha water (in 1931) was in the region of 0·003 N., that of Nakuru about 0·18 N. We know, however, that Lake Naivasha, like Lakes Nakuru and Elmenteita, has contracted very much in volume. It was once 380 feet above its present level (Leakey, 1931 *a*). To account for the freshness of the Naivasha water, Gregory (1921, p. 247) suggested that the lake has an underground outlet and that there is in reality a continual flow through.

Leakey (1931 *a*) pointed out that the upper branch of the Malewa River rises in the Aberdare Mts., and flows due north before turning sharply back to flow into Lake Naivasha in a S.W. direction. He suggested that this branch at one time flowed independently into Lake Ol Bolossat to the north, and that comparatively recently it has been diverted by earth-movements to join the Malewa. As a result of this change, Lake Naivasha began to receive a much greater water supply than formerly, and its waters were diluted. The fact remains, however, that there has been a great contraction of the lake to very roughly one-twentieth of its maximum volume, and that, other conditions remaining constant, were it to contract to one-tenth of its present volume its alkalinity would be of the order of 0·03 N., or only one-sixth that of Lake Nakuru.

There are two further points which are of importance in this connection. In the first place, the level of Lake Naivasha never rose to as great a height as did that of Lakes Nakuru and Elmenteita. When the waters of Lake Naivasha reached a height of 380 feet above their present level, they overflowed through the Njorowa gorge to the south. But the level of Lake Nakuru rose twice this distance (750 feet), and was still a closed drainage basin. Lakes Nakuru and Elmenteita have, therefore, contracted from a very much greater volume than has Lake Naivasha, and their waters would, for this reason alone, be expected to be of a higher salinity. In the second place, the salt content of a lake depends, not only on changes of volume due to evaporation, but also on the salinity of the waters flowing into it. Springs of high soda content are common in the Rift Valley, but none have as yet been discovered flowing into Lake Naivasha. The waters of the River Malewa, the main supply to the lake, were in November 1930 of low alkalinity (0·00064 N.).*

The water of the River Kariandusi flowing into Lake Elmenteita was in 1929 definitely alkaline (0·0025 N.) (Jenkin, 1932 *a*, p. 547), and a hot spring flowing into Lake Nakuru on the east shore had, in February 1931, an alkalinity of 0·019 N. The higher soda content of Lakes Nakuru and Elmenteita is thus partly due to the higher soda content of their water-supply.

With both these factors taken into consideration, it is still improbable that the present comparatively low alkalinity of Lake Naivasha can be explained without the assumption of an outlet. We can assume that the alkalinity, when the lake was at its highest level, was at least as high as that of the present rivers flowing into the lake (0·0006 N.). If, for argument's sake, this alkalinity were supposed to be due mostly to calcium (which is unlikely in a country of soda-bearing lavas), vast quantities of calcium would have been deposited during the process of evaporation. For this there is no evidence. At present 70 per cent. of the total alkalinity (0·003 N.) is due to sodium carbonate (0·002 N.). The concentration of sodium carbonate in the lake at its highest level, on the assumption that there has been no outlet and that it has since evaporated to one-twentieth of its volume at that time, would have been about 0·0001 N. It would in reality have been considerably less, since sodium carbonate must have been introduced continuously since then by rivers. The existence of a lake containing so little sodium carbonate seems unlikely in view of the prevalence of soda-bearing lavas.

A subterranean outlet thus affords the only reasonable explanation of the comparative freshness of the Lake Naivasha water. Its occurrence is by no means improbable in a country where much faulting has taken place. The water table in the Kedong Valley, south of the Naivasha basin, suggests that the lake is draining to the south (Solomon, J. D., in Leakey, 1931 *b*, p. 258). The relative changes of water-level, which have occurred in the Nakuru, Elmenteita, and Naivasha basins, seem to lend some support to this conclusion.

* Its alkalinity in July 1929 was 0·00067 N. (Jenkin, 1932 *a*, p. 547).

The following figures are taken from Leakey (1931 *a*) :—

Periods (beginning early Pleistocene).	Heights of lakes (in feet) above present level. Lake Nakuru.	Lake Naivasha.
1st major pluvial period (Kamasian)	—	—
Dry period of volcanic activity and faulting (formation of lake basins)	—	—
2nd major pluvial period.		
Lower Gamblian	750	380
Pause (relatively dry)	150	100
Upper Gamblian	500	180
Very dry period	0 ?	0
1st post-pluvial wet phase	375	100
Dry period	0 ?	0 ?
2nd post-pluvial wet phase	150	50
Change to present conditions	—	—

It can be seen from these figures that, during the dry interval subsequent to the lower Gamblian wet period, the level of Lake Nakuru fell a much greater distance than did that of Lake Naivasha. As is the case at the present time, the latter may have had a much greater catchment-area relative to the surface-area of the lake than had the former. We must assume, therefore, that, previous to the Upper Gamblian period, there was no outlet to Lake Naivasha. During all the subsequent wet-phases, however, Lake Naivasha has never risen to the same extent as has Lake Nakuru. These facts might be explained on the assumption that, some time during the dry pause in the 2nd major pluvial period, faulting occurred to produce a subterranean outlet for Lake Naivasha, with the result that it never again rose to the same extent as did Lake Nakuru.

We were unable to find any indication of the position of this outlet. Gregory's suggestion that it occurs in the S.W. bay was, however, definitely disproved (Gregory, 1921, p. 245). Our soundings showed that this bay did not exceed 14½ metres in depth, and the fact that the alkalinity of the water was here greater than that of the main lake (S.W. bay 0·00427 N., Lake 0·003 N.) precluded the possibility of an outlet in this bay. Owing to the shallowness of the lake, and to the great amount of wind-mixing which occurs, it was to be expected that little difference would be found between the composition of the surface- and bottom-waters. In a deeper lake, less subjected to wind-mixing, the composition of the surface- and bottom-waters would approximate more closely in the region of a subterranean outlet than elsewhere.

Large aquatic vegetation.

The years 1928–9 were unusually dry, and when visited by Miss Jenkin in July 1929 the lake was about 7 ft. below its level in November 1930. The rains which occurred in late 1929 and early 1930 were very heavy, and the lake rose to the highest recorded level since 1917. This change of level was accompanied by a great change in the large aquatic vegetation. In July 1929

the north and east shores were bounded by wide mud-flats (Jenkin, 1932 *a*, p. 549), whereas, in November 1930, this region was submerged and was covered by a dense growth of *Papyrus*. Presumably the fall of the lake level during the dry period previous to July 1929 had been too rapid for the *Papyrus* to gain a footing in water of the optimum depth. The rise in the lake level was also accompanied by a great increase in growth of the submerged vegetation (water-weeds). In July 1929 the area included between the east shore and a line north and south through Crescent Island was open, easily navigable water, except for a narrow strip close inshore where water-weeds were abundant. In November 1930 this area was entirely choked with *Ceratophyllum* and *Potamogeton*, in many places reaching the surface. A more detailed account of the aquatic vegetation of the edge of the lake is given in another paper (Beadle, 1932, p. 138).

The period from November 1930 to May 1931, during which periodic observations were made, was, compared with the previous year, relatively dry, and, in spite of a certain amount of rain in April 1931, the lake level had fallen about 18 in. by the end of that period. This sinking of the lake level was accompanied by a gradual dying out of the water-weed, and by certain changes in the composition of the water, particularly in an increase of phosphate (see section on composition of water).

Plankton.

Collections made in November 1930 and in February 1931 showed that the plankton of the surface-water was essentially similar, both within Crescent Island (Station 30), and in the centre of the lake (Station 18). Plankton counts were made on samples collected in February and May 1931.

An analysis of these samples of surface-plankton from the Crescent Island Station (30) is given in Table II. In February the phytoplankton consisted of great numbers of the filamentous diatom *Melosira* and of relatively few Chlorophyceae and Cyanophyceae. The zooplankton was abundant, but only two genera were represented (*Cyclops* and *Moina*). In May 1931 the

TABLE II.

	Date.	Diatoms (*Melosira*).	Cyanophyceae and Chlorophyceae (various).	Zooplankton.
Crescent Island, Sta. 30.	26. ii. 31.	1,780 per litre.	66	*Cyclops* (many). *Moina* (many).
	11. v. 31.	240 ,,	>10	*Moina*+rotifers (many).
S.W. Bay, Sta. 38..	8. iii. 31.	10 ,,	nil	*Cyclops* (many). *Moina* (few). *Hydrachnida* (few).

numbers of both *Melosira* and Chlorophyceae had considerably decreased, and a large number of rotifers had appeared in the zooplankton.

The plankton of the S.W. bay (Station 38) was very different. The water was almost devoid of phytoplankton. Only a very few *Melosira* were found, and no Chlorophyceae. The zooplankton comprised the same genera of Crustacea, and in addition a few hydrachnids (Table II). It will be shown later that the water of the S.W. bay was different from that of the main lake.

The much richer and more varied fauna and flora of the weed and swamp regions at the edge of the lake is described elsewhere (Beadle, 1932, p. 141).

Composition of the surface waters.

A total analysis (by the Govt. Chemist, London) of a surface sample collected in December 1930, from Crescent Island (Station 30), is given in Table XV. A rough calculation will show that about 60–70 per cent. of the total alkalinity was due to sodium carbonate. It was noticed that considerable quantities of calcium carbonate were deposited upon the leaves of *Potamogeton* in the shallow waters.

TABLE III.

Surface-samples.

Station.	Date.	Alkalinity.	pH (mdy.).	P_2O_5 (mg. per litre).	SiO_2 (mg. per litre).
Cresc. I. (30) ..	23. xi. 30.	0·00290 N.	9·1	nil	33
	26. ii. 31.	0·00302	8·5	nil	20
	4. v. 31.	0·00291	8·8	0·09	—
Cent. Stn. (18) ..	23. xi. 30.	0·00288	9·0	nil	25
	8. iii. 31.	0·00303	9·0	nil	—
¾ mile from W. shore (25).	26. xi. 30.	0·00288	9·1	nil	20
S.W. Bay (38) ..	8. iii. 31.	0·00427	8·6	nil	—
R. Malewa (2 miles from mouth).	25. xi. 30.	0·00064	7·8	trace	15·4

Some figures for the alkalinity, pH, phosphate, and silicate content of surface samples, taken from different parts of the lake at different dates, are given in Table III. Certain interesting changes are shown by the samples from Crescent Island Station (30). Between November 1930 and February 1931 there was an increase of alkalinity due to an intervening period of dry weather. During the period between February and May 1931 the rainfall increased, and at the beginning of May the alkalinity had returned to the November value.

Samples taken on 8. iii. 31 from the Central Station (18) and the S.W. Bay (38) show that the alkalinity of the latter was considerably higher than that of the lake. Since the bay was connected with the lake by only a narrow

channel, this condition was not unexpected. The midday pH of the water inside the bay was lower than that of the main lake water. This accorded with the difference between the phytoplankton at the two stations. The phytoplankton of the main lake was abundant, that of the bay was very scarce (Table II).

Silicate appeared to be abundant at all the Stations investigated. Even higher values (41–69 mg. per litre) were obtained by Miss Jenkin from the surface-waters of this lake in June 1929 (Jenkin, 1932 *b*).

The figures for phosphate content in Table III show that no phosphate was detected in the surface-waters until May 1931, though a considerable quantity was found in the deepest water at Crescent I. Station in November 1930 (see below, Table V). As already stated the minimum quantity detectable by the method as used on this expedition was of the order of 0·01 mg. per litre. It seems, therefore, that, since the surface-waters in November 1930 and February 1931 supported a large phytoplankton, the phosphate was being used up as rapidly as it was formed by decomposition of organic matter, so that the actual amount in solution at any given moment did not exceed 0·01 mg. per litre. Complete depletion of phosphate is known to occur in the surface-waters of tropical seas (Atkins, 1926).

TABLE IV.

	Surface-samples. 23. xi. 30.	25. ii. 31.	P_2O_5 mg. per litre. 4. v. 31.
1. Swamp	1·26	1·07	0·23
2. *Ceratophyllum* zone (27)	nil	nil	0·11
3. Crescent Island Stn. (30)	nil	nil	0·09

It is interesting to compare the phosphate determinations made at different dates on surface-samples from three positions: (1) In the papyrus swamp on the east shore opposite Crescent I., where the water was about 2 feet deep, (2) in the water-weed zone (*Ceratophyllum*) between the swamp and the island, and (3) at Crescent Island Station. The results are given in Table IV. In November 1930 and February 1931, when no phosphate was detected in the open waters of the lake, it was abundant in the swamps at the edge. In May 1931 there was less phosphate in the swamp water, but it was found to be present in reasonable quantities in the open lake water. There are two possible explanations of this change. Firstly, both in November and February there was an unprecedented growth of submerged water-weed, due presumably to the exceptionally heavy rainfall of the middle of 1930 (see above, section on aquatic vegetation), which would have caused an inflow from the surrounding land of waters rich in nutrient substances. The consequent outburst of aquatic vegetation had by November 1930 reduced the phosphate to a very low value (except in the swamp where the weed was relatively scarce).* In May 1931

* The analysis by the Govt. Chemist, London, of a surface-sample collected in December 1930 showed that no NO_3 and NO_2 was detected (Table XV).

there had been considerable dying-off and decomposition of the weed, and the water, previously quite clear, was then slightly cloudy. The increase of phosphate at that time might be attributable to the decomposition of plant matter. Secondly, the occurrence of a rainy period between February and May, which resulted in a reduction of alkalinity (Table III), would have caused a certain increase in the phosphate of the lake, owing to the inflow of phosphate-rich waters from the land. This was shown to occur in the case of Lake Baringo (see below).

Analyses of samples from different depths.

A comparison between surface and bottom samples from Crescent I. Station (30), taken in Nov. 1930 and Feb. 1931, is of interest. Analyses of these are given in Table V.

On 23. xi. 30 the alkalinity of the lower water was higher and the pH lower than those of the surface-water. There was also a large amount of phosphate present at the bottom, which was absent from the surface. Temperature measurements were unfortunately not made at that time. It seems, however,

TABLE V.

		Alkalinity.	pH (mdy.).	P_2O_5.	SiO_2 (mg. per litre).	O_2 (c.cm. per litre midday).
Crescent I.,	Surface	0·0029 N.	9·1	nil	33	5·46
23. xi. 30.	18 ms.	0·0031	7·8	1·04	33	3·54
Sta. 30, 26. ii. 31.	Surface	0·0030	8·5	nil	20	5·50
	18 ms.	0·0030	8·4	nil	20	3·70

that the lower water within Crescent Island was not being mixed with the water of the upper layers * to the same extent as in February 1931. The figures for the latter date (Table V) show that the alkalinity was equal at the surface and bottom, and that the pH was generally lower, presumably as a result of daily mixing of the upper and lower waters. This mixing might account for the disappearance of phosphate from the bottom, which would have been brought to the upper layers and consumed by the phytoplankton.†

The onset of a period of heavy winds, which began towards the end of January, must have caused this mixing of the upper and lower layers of water. Measurements of changes throughout 24 hours were made on samples from various depths at Crescent I. Station (30), and in the *Ceratophyllum* zone where the depth of water above the weed was 2½ metres.

1. The results from Crescent I. Station are given in text-fig. 1. The alkalinity, phosphate, and silicate content were found to be identical from top to bottom

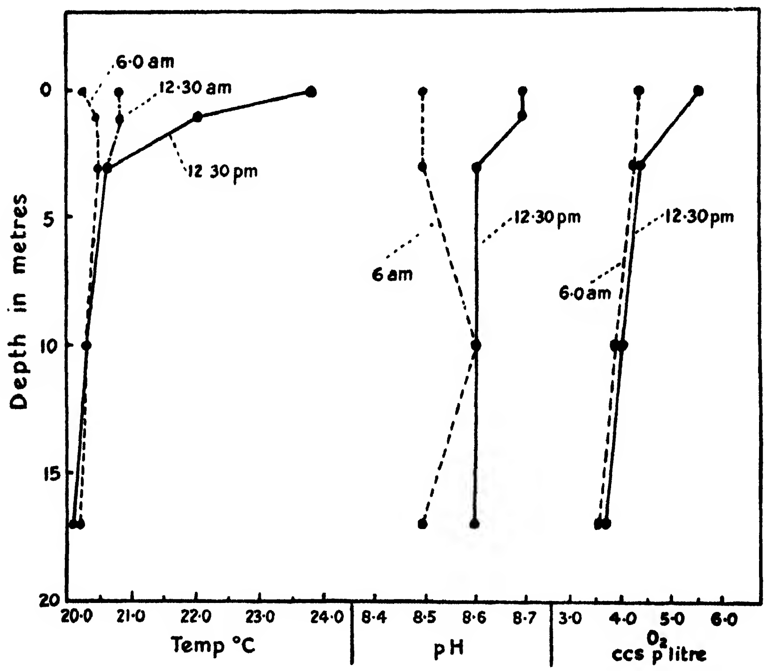
* If it is true that there was layering of the water at this time, the small diminution in oxygen content of the lower water (Table V) suggests the condition had only recently developed.

† Bottom samples were of necessity taken from at least 1 metre above the bottom to avoid taking up mud,

13*

throughout the period. The temperature curves show that there was a steep temperature gradient in the upper 3 metres at midday which was reversed at dawn, and that there was no thermocline. Thorough mixing must therefore have taken place every night. The fact that the alkalinity was equal at all depths also supports this conclusion. In measuring the pH, which fluctuated on the thymol blue range, it was found that it was impossible to match the tints against the chart at night, since the artificial illumination was yellow (oil lamp). Only the determinations made in daylight (dawn and midday) are recorded in text-fig. 1. These curves show an increase of pH in the surface-water from 8·5 to 8·7 between dawn and midday. This corresponds to a change in total CO_2 content of 1·5 c.cm. per litre.

TEXT-FIG. 1.



The oxygen curves show that at dawn there was little diminution in oxygen content in the deeper layers, and that at midday there was a considerable rise in that of the surface-water to a depth of (probably) about 5 metres. The oxygen contact at midday in the surface-water reached 94 per cent. saturation.

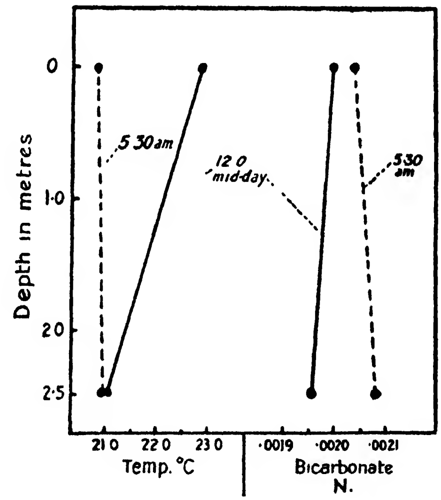
2. Dawn and midday observations of temperature and CO_2 content, made on the water of the *Ceratophyllum* zone (Station 37), are given in text-fig. 2. There was a depth of 2½ metres above the weed. Here, again, we see a reversal of the temperature gradient at night, with consequent complete mixing.

The pH of the surface-water fluctuated between about 9·1 and 9·3. This,

owing to the greater amount of plant matter present, is a higher value than that found at Crescent I. Station (30). The pH being above 9·0, more reliable estimations of the change in CO_2 content could be made by estimating the change of bicarbonate content (see section on methods). Text-fig. 2 shows that there was a greater reduction in the CO_2 content of the lower water at midday than in that of the surface-layer. This might have been expected in view of the large amount of weed on the bottom.

These changes in bicarbonate content represent a change in total CO_2 content of 0·45 c.cm. per litre at the surface, and of 1·8 c.cm. per litre at the bottom.

TEXT-FIG. 2.



Penetration of light effective for photosynthesis.

To determine the depth to which sufficient light penetrated for photosynthesis, bottles were suspended at different depths at Crescent I. Station (30) in the manner already described (section on methods). Into them were placed pieces of *Ceratophyllum* as near as possible of the same size. Each piece consisted of 10 terminal nodes of a branch. The results are recorded in text-fig. 3 together with results of a similar experiment on Lake Baringo.

Two experiments were done on two successive days :—

(*a*) 2. iii. 31. Bottles exposed 9.45 a.m.–2.15 p.m. (4½ hours). Cloudless sky.

(*b*) 3. iii. 31. Bottles exposed 10.15 a.m.–3.15 p.m. (5 hours). Cloudless sky 10.15–12.45 p.m. Cloudy sky 12.45–3.15 p.m.

It will be seen that on the sunny day (*a*) the maximum amount of oxygen was produced at 1 metre, whereas on the day of which the latter half was cloudy the maximum amount was produced at the surface. We can conclude therefore that on a cloudless day the optimum light intensity is at a depth

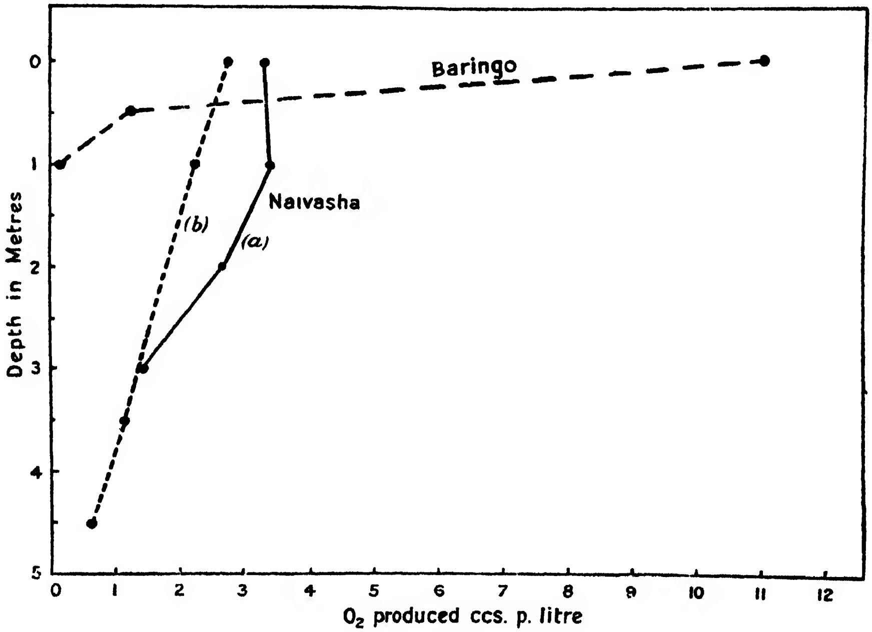
of about 1 metre, and that when the sky becomes cloudy the position of optimum light intensity moves to the surface. Text-fig. 3 also indicates that light effective for the photosynthesis of *Ceratophyllum* does not penetrate deeper than about 5 to 6 metres—5 metres was, in fact, the maximum depth at which *Ceratophyllum* was found growing in the lake.

A comparison between these and similar experiments done on Lake Baringo will be made in the section on that lake.

Changes during period of observation (summary).

After Lake Naivasha was visited by Miss Jenkin in July 1929 there was a period of exceptionally heavy rainfall, which caused a rise in the lake level and a lowering of the alkalinity. The inflowing waters probably brought

TEXT-FIG. 3.



nutrient substances into the lake from the land, which caused an unprecedented growth of aquatic vegetation. In November 1930, when the lake was first visited by the expedition, this growth of vegetation was reaching a maximum and the phosphate content of the water was very low. This was also a relatively calm period, and the phosphate-rich deep waters within Crescent Island did not circulate with the upper layers to any great extent.

Towards the end of January 1931 a period of heavy winds began, and at the end of February there was complete daily circulation of the layers of water. This probably prolonged the life of the aquatic vegetation which was then abundant, though the phosphate content of the water was still low.

In May 1931 the weed had to a great extent died out, and the phytoplankton within Crescent Island had decreased. The phosphate content of the water had, however, increased, owing presumably to the decomposition of the dead plant matter and to an intervening rainy period in April. It is difficult to understand why the aquatic vegetation had not already started to increase again in May 1931, when the phosphate content had risen.

NAIVASHA CRATER LAKE (visited 1. iii. 31).

This is situated about 1 mile from the western shore of Lake Naivasha (Station 33). In diameter about ¼ mile, it is surrounded by nearly vertical sides about 100 feet high, which are the walls of an extinct volcanic crater. Soundings showed that the maximum depth of the water was 9 metres.

The phytoplankton consisted solely of vast numbers of the blue-green alga *Arthrospira platensis*. The following numbers were found in samples from different depths :—

Surface	215×10^5 per litre.
4·5 metres	698×10^4 ,,
8·5 metres	177×10^4 ,,

The zooplankton consisted of a large number of *Diaptomus*. No other organisms were found.

Results of determinations of alkalinity, pH, and phosphate are given in Table VI. The alkalinity was very high, and, since the catchment-area is little greater than the area of the lake itself, it is reasonable to conclude that

TABLE VI.

1.3.31, 2 p.m.

	Alkalinity.	pH.	P_2O_5 (mg. per litre).
Surface	0·084 N.	>10·3	0·81
8·5 metres	0·125	10·0	3·50

large quantities of soda are derived from some source within the crater, which has no connection with the water supply to Lake Naivasha. The alkalinity of the bottom water was much higher than that of the surface-layer, which also indicates that soda-rich water was seeping up from below.* The much higher phosphate content of the bottom water than that of the surface suggests that there was little mixing of the upper and lower layers. This absence of mixing was probably due partly to the presence of the more saline and, therefore, heavier layer at the bottom, and partly to the thorough protection against winds afforded by the high walls of the crater. No temperature measurements were made.

In June 1929 the plankton of this lake comprised a similar quantity of *Arthrospira* and some rotifers (*Brachionus pala*). The alkalinity of the water at the edge was 0·117 N. (Jenkin, 1932 *a*, p. 547).

* The water from 8·5 metres smelt strongly of H_2S, the surface-water was odourless.

LAKE BARINGO (0° 35′ N., 35° 55′ E.; altitude 3,150 feet; surface-area 66 sq. miles).

General.

This lake is situated in the Eastern Rift about 80 miles north of Naivasha. The floor of the valley, which is at its maximum altitude in the Naivasha region, is here some 3,000 feet lower. The climatic conditions are therefore different, the temperature is higher and the humidity is lower (see Table I). A plan of the lake and its surroundings will be found in Map 5, together with the stations at which observations were made. The soundings show that the depth probably nowhere exceeds 7½ metres. The Islands, situated south of the centre of the lake, are the remnants of an early Pleistocene volcano (Gregory, 1921, p. 111).

The water was greenish in colour, owing to the presence of vast quantities of the blue-green alga *Microcystis*. Even when filtered it had a dirty brown colour. Secci's disc disappeared at 8 ins. in the open water (Station 121; midday, 7. 12. 30).

Lake Baringo was visited twice by the expedition from 3 to 9 December 1930 and from 25 January to 1 February 1931. On both these occasions the weather conditions were strikingly similar from day to day. There was a dead calm in the morning which lasted until 4–6 p.m., when a stiff N.E. breeze arose and continued until about 9 p.m. and the calm was again resumed. Owing to the shallowness of the lake the waters were completely mixed by this wind every day.

Water supply and subterranean outlet.

The lake is supplied with water at the south end by the Rivers Tiggeri and Ol Aribel, which receive their supply from the Elgeyo escarpment and from the north end of the Mau escarpment. As is shown in Map 5, the mouth of this river was (in 1930–1) choked with swamp, which fringed the entire south shore. Water samples were collected from the River Tiggeri at the ford at Marigat (Station 111).

On the largest volcanic island (Ol Kokwa) are a number of hot springs which discharge into the lake (Station 128). The water of these in February 1931 was of a higher alkalinity (0·032 N.) than that of the lake water (0·0057 N.). These springs were first discovered in 1903 by Powell Cotton (1904).

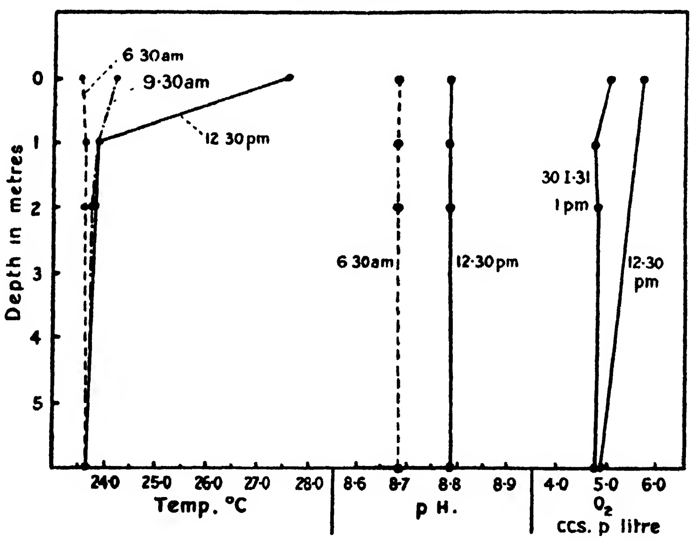
Since there is no surface-outlet, and the discovery of beaches has shown that the water-level was at one time at least 50 feet higher than at present (Gregory, 1921, p. 108), it is most probable that the comparatively low alkalinity of the water, in spite of the inflow of soda springs, indicates that there is somewhere an underground outlet. This was, in fact, confirmed by Gregory in 1893, who noted that 'At several points along the north-east shore the waters were pouring freely into the lavas' (Gregory, 1921, p. 107).

Gregory considers that the lake at its highest level flowed over the Lobat pass to the north. This pass subsequently became raised, and the whole lake basin was tilted up towards the north. The present underground outlet probably feeds the springs of the Kogore Valley, which, 5 miles from the lake on the northern side of the Lobat pass, is 100 feet below the level of the lake (Gregory, 1921, p. 107). Evidence of recent higher levels of the lake was found in two water-marks on a small volcanic island S.E. of Ol Kokwa Island, at heights of 8½ and 16½ feet above the water.

Large aquatic vegetation.

It was to be expected that, as in the case of Lake Naivasha, the water-level had risen since 1929, when the lake was visited by Miss Jenkin, owing to the period of high rainfall which had intervened. No comparison of water-levels could be made, but, as would be expected, the alkalinity of the water which in 1929 was 0·01 N. (Jenkin, 1932 *a*, p. 547) had fallen in December 1930 to 0·0055 N.

TEXT-FIG. 4.



In June 1929 the south end of the lake was devoid of large aquatic vegetation (Jenkin, 1932 *a*, p. 548), but, owing no doubt to the intervening period of high rainfall, there was in December 1930 a large area of swamp at the south end. This swamp comprised small areas of *Papyrus* and of a reed (*Paspalidium geminatum*), and large areas of *Pistia*, *Azolla*, and water-lilies. Amongst the latter were found at least three species of water-weeds (*Utricularia* sp., *Ceratophyllum demersum*, and *Najas minor*). The Ambatch tree (*Herminiera claphroxylon*) was growing in large numbers in the shallow water at the swamp edge.

With the exception of the south end, the S.E. and S.W. corners, the shore was rocky and devoid of large aquatic vegetation. No water-weed was found anywhere in the lake except in the swamp at the south end.

Water temperature.

The dawn to midday temperature changes of the open water (Station 121) on 31. i. 31 are recorded in text-fig. 4. There was a large temperature gradient of 4° C. in the first metre at midday, which at dawn became a reverse gradient of about 0°·1 C. Both the midday and the dawn reverse gradients were continued from top to bottom, and the bottom temperature at midday was 0°·01 C. higher than at dawn. There is, in fact, less lag in the surface-temperature changes affecting the bottom water, as was found in the deeper water of Lake Naivasha (16 metres), where the bottom temperature at midday was slightly lower than at dawn (see text-fig. 1). This difference is probably due, not only directly to the shallowness of Lake Baringo, but also to the more extensive stirring by winds in the Baringo basin.

The surface-temperatures recorded in text-fig. 4 were taken with a reversing thermometer at a depth of about 2 ins. A single measurement made with a hand thermometer at midday showed that the temperature of the water within 1 inch of the surface may reach 30° C. on a sunny day.

Plankton.

Plankton collections were made in the open water in December 1930 and at the end of January 1931. No appreciable change had taken place during that time.

It will be seen from Table VII (2) that, compared with Lake Naivasha, the number of diatoms was much smaller, but that Cyanophyceae (*Microcystis* and *Aphanocapsa*), which were rare in Naivasha, were abundant and were mainly responsible for the green colour of the water.

TABLE VII.

Surface-samples.

(1)	July 1929 (Jenkin).	4. xii. 1930.	30. i. 1931.
Alkalinity	0·01 N.	0·0055	0·0057
SiO_2 (mg. per litre)	trace	18·2	15·8
P_2O_5 (mg. per litre)	—	1·37	1·25

(2) Plankton (29. i. 31).	Cyanophyceae (*Microcystis, Aphanocapsa*).	Diatoms. *Melosira.*	Diatoms. *Nitzschia.*	Zooplankton.
Nos. per litre	1000	620	<10	*Diaptomus.* *Cyclops.* *Moina.* *Daphnia.* *Ceriodaphnia.* *Diaphanosoma.*

The zooplankton comprised a number of species which were absent from the open water of Lake Naivasha. Some of these, however (*Daphnia* and *Diaptomus*), were living in the swamps at the edge of Lake Naivasha.

Water analyses.

A total analysis by the Government Chemist of an open-water sample (Station 121) is given in Table XV. Compared with Lake Naivasha there was a higher concentration of every ion except Mg.

(a) *Alkalinity.*—From 7 December 1930 to 26 January 1931 the lake level had fallen by about 1 foot. This was accompanied by an increase in alkalinity of the open water from 0·0055 N. to 0·0057 N. There was no detectable variation in alkalinity of different regions of the open lake, except in the immediate vicinity of the hot springs of Ol Kokwa Island (Station 128). These were discharging water of an alkalinity of 0·032 N. (2 February 1931). The dawn and midday determinations made on samples from different depths (Station 121) showed no detectable difference in alkalinity from top to bottom. This was presumably the result of the violent mixing by the regular afternoon wind.

The alkalinity of the water of the River Tiggeri at Marigat (Station 111) on 7 December 1930 was 0·00089 N. (pH 8·2). It appears that, if there is an underground outlet, the bulk of the soda of the lake is derived from underground sources.

(b) *pH and CO_2 content.*—The curves of text-fig. 4 show that on 31.i.31 there was a diurnal change of pH in the open water from 8·67 at dawn to 8·79 at midday. This represents a change in total CO_2 content from 124·9 c.cm. per litre (at N.T.P.) to 123·1 c.cm. per litre at midday. About 1·8 c.cm. per litre of CO_2 were therefore assimilated by the phytoplankton between dawn and midday, which is 20 per cent. more than the volume assimilated by the open-water phytoplankton of Lake Naivasha (1·5 c.cm. per litre).

It is difficult to see why the midday rise of pH should be found to occur even in the lower layers; indeed, it would appear impossible in view of the experiments on the oxygen production of algae (to be described later), which show that little photosynthesis occurred below the first metre. There was, however, little diminution of oxygen with increasing depth, which indicates that the water was well mixed.

(c) *Oxygen content.*—The two curves representing O_2 content at different depths in text-fig. 4 are constructed from determinations made at midday on two successive days (30 & 31 January 1931). The first of these days was cloudy until midday, the second was unclouded. This is reflected in the greater amount of O_2 produced by photosynthesis at the surface on the second day, when 105 per cent. saturation was reached. In spite of the fact that little photosynthesis occurred below the upper metre (see photosynthesis experiments), the bottom water contained oxygen at 81 per cent. saturation. This can only be attributed to the mixing caused by the powerful daily winds.

(d) *Phosphate content.*—Owing to the colour of the water these determinations cannot be considered to be as accurate as those done on other lakes. There is no doubt, however, that the phosphate content was very high compared with Lake Naivasha. Estimations made on surface-samples from Station 121 on 6. xii. 30 and 31. i. 31 gave 1·37 and 1·28 mg. P_2O_5 per litre. Surface and bottom (6 metres) samples taken on 31. i. 31 showed no appreciable difference in phosphate content (1·28 mg. per litre).

The phosphate content of the River Tiggeri at Marigat (Station 111) on 7. xii. 30 was greater than that of the lake (1·92 mg. per litre). The river was then comparatively high as a result of the recent ' short ' rains of November, and the phosphate was presumably being washed in from the surrounding land. On 5. ii. 31 the river was much lower owing to the intervening drier period, and the water contained only a faint trace of phosphate.

As shown above (Table VII (1)) the phosphate content of the open lake water was higher in December than in January. It therefore seems probable that the phosphate of the lake is increased in the rainy seasons and diminished in the intervening dry periods.

(e) *Silicate content.*—Surface-samples from Station 121 on 4. xii. 30 contained 18·2 mg., and on 31. i. 31 15·8 mg. SiO_2 per litre. As in the case of the phosphate, the silicate content was found to be identical at the surface and bottom (31. i. 31).

Changes since 1929.

Some interesting changes occurred in the composition of the open water between July 1929 (when visited by Miss Jenkin) and the beginning of December 1930, and between the latter date and the end of January 1931. These are summarised in Table VII (1).

The great lowering of alkalinity between the first and second dates and the slight rise between the second and third dates were obvious consequences of the intervening periods of heavy rainfall and of dry weather respectively. The large increase in silicate content and its subsequent slight decrease would seem to indicate that the silicate is replenished from the surrounding land during periods of rain, and is decreased in subsequent dry periods, as is probably the case with the phosphate (see section on phosphate).

Penetration of light effective for photosynthesis.

Experiments were done by the method previously described. A culture of *Microcystis* and *Melosira* was obtained by passing a sample, collected from the lake in a fine plankton net, through coarse-meshed bolting silk to remove the majority of the larger zooplankton. The liquid so obtained comprised a dense suspension of phytoplankton which was diluted to the required volume with filtered lake-water. This was shaken, placed in Winkler bottles, and left for the night (with the stoppers removed) so that the oxygen content should be considerably below saturation. Three pairs of bottles, covered and uncovered, were suspended at the surface, at 0·5 metre, and 1 metre at Station 121.

The amounts of oxygen produced in the uncovered bottles, allowing for the volume absorbed by respiration in the covered controls, are plotted in text-fig. 3, together with the results of the experiments done on Lake Naivasha. They were left for $4\frac{1}{2}$ hours between 9.45 a.m. and 2.15 p.m., during which time there was a cloudless sky. The final oxygen content of the uncovered bottle at the surface amounted to about 240 per cent. saturation. A high pressure was presumably developed in the bottle.

It will be seen that most O_2 was produced at the surface and that the rate of photosynthesis fell off very rapidly with increasing depth. At 1 metre practically no oxygen was produced (0·02 c.cm. per litre). This is a great contrast to the condition in Lake Naivasha, where sufficient light for photosynthesis penetrated to at least 4·5 metres, and where on a cloudless day the optimum light intensity was found at about 1 metre (fig. 3, Naivasha (*a*)), instead of at the surface as in Lake Baringo. This is a good illustration of the difference in opacity between the waters of these two lakes.

It must be remembered that no comparison can be made between the absolute amounts of oxygen produced in the bottles in these two lakes, since different amounts of plant-material were used in each case. In each experiment, however, the amount of plant-material was as near as possible equal in all the bottles.

Lake Hannington.

Lake Hannington is situated in the Eastern Rift Valley about 10 miles south of Lake Baringo. Lake deposits in the region between these two lakes show that they were at one time connected. It is a narrow lake about $\frac{1}{4}$–$\frac{1}{2}$ mile in breadth by about 4 miles in length. The north end was visited for a few hours (on 4. ii. 31) on the return journey from Baringo to Naivasha, and the samples collected were not examined until three days later at Naivasha.

The lake was extremely alkaline (0·16 N., Station 134), and at the north end it was very shallow. There were white deposits of soda round its shores. The phosphate content of the sample from Station 134 was 1·73 mg. P_2O_5 per litre.

The plankton consisted of vast numbers of the spiral blue-green alga *Arthrospira* and some rotifers. As a result, the water was bright green in colour.

Lake Hannington is noted for its flamingoes, which are found in such large numbers that the lake, viewed from a distance, appears to be covered with sheets of pink. These birds, as shown by Miss Jenkin, feed on the blue-green algae (Jenkin, 1929, p. 574).

There was a slow-flowing stream entering the lake at the north end (Station 132), the alkalinity of whose water was, compared with that of the lake, very low (0·0064 N.). But this figure is high enough to warrant the conclusion that the stream was probably receiving a supply of soda from some alkaline spring. The phosphate content of the stream-water (1·92 mg. per litre) was even higher than that of the lake.

Both Lakes Baringo and Hannington are, therefore, receiving soda-rich waters. It is probable, then, that the great difference in alkalinity between the waters of Lakes Baringo and Hannington is due to the presence of an underground outlet to the former and of no outlet to the latter.

Lake Rudolf (4° N., 36° E.; altitude 1,250 feet; surface-area about 3,600 sq. miles).

General.

After Lakes Tanganyika and Nyassa, this is the largest of the Rift Valley lakes. It lies in northern Kenya on the Abyssinian border, at a point at which the floor of the eastern Rift is at its lowest. Its altitude is nearly 3,000 feet lower than that of Lake Baringo. The air-temperatures are therefore considerably higher, and the percentage humidity lower (see Table I).

Heavy winds were experienced almost every day. The prevailing wind was from the S.E., which has caused the formation of the sand-spit enclosing Ferguson Bay. On a typical day the S.E. wind would rise about 9 a.m., continue with increasing violence until about 3 p.m., when it would veer round to the N.E. In the evening, and throughout the night, a calm would usually prevail.

Two visits were made to the lake—25 December 1930 to 11 January 1931 and 20 March to 22 April 1931. On both occasions the base of operations was at the mouth of the River Kaliokwell about half-way up the west shore. A map of this region is given (Map 2). This includes the area of water on which most of the work was done, together with Central Island with its three crater lakes (about 12 miles from the west shore), and the sand-spit which projects from the shore in a northerly direction and encloses an area of water of about 2½ sq. miles (Ferguson Bay). These crater lakes and Ferguson Bay were of great interest in that their waters were chemically different from that of the main lake, and a corresponding difference was found in their fauna and flora.

The water of the open lake was very alkaline (alkalinity about 0·02 N.), for which reason it was unpleasant as a drink. Count Teleki, the original discoverer of the lake, on reaching the south end in 1888, neutralized the water with tartaric acid before drinking (von Höhnel, 1894, vol. ii, p. 98). We found that the addition of citric acid produced an effervescent drink more pleasant than the untreated lake water, but that its high total salt content diminished its thirst-quenching properties.

The lake is in this region about 35 miles wide. Soundings made eastwards across the lake from the mouth of the River Kaliokwell are shown in Map 2. The maximum depth found was 69 metres. It seems probable that the lake is nowhere much deeper than this.

There were neither time nor facilities to investigate thoroughly any other part of the lake, though a short visit was made by Dr. Worthington to the east shore opposite the Kaliokwell and to the mouth of the River Turkwell, and by

myself to a point at the northern end of the west shore at the foot of Mt. Laburr. The political situation on the Kenya–Abyssinia border made impossible a visit to the rivers Omo and Kibish at the northern end.

Water supply and former lake levels.

The rainfall in the immediate vicinity of the lake is extremely low, and for some 10 miles inland from the west shore the country is a sandy semi-desert. There are a number of small rivers, such as the Kaliokwell, which drain the nearer hills, and which flow for only a few days or even hours in the year during the local rains. But it is probable that there is a continual slow underground seepage of water into the lake in the sand of these river-beds. In some of them fresh water could be obtained by digging in the sand within a mile of the lake. In the Kaliokwell river-bed a water-hole was dug in March 1931, ½ mile above the last alkaline pool (alkalinity 0·1 N.) left by the lake which had recently receded. The water obtained from this had an alkalinity of 0·0014 N., and was, therefore, suitable for drinking.

The River Omo at the north end affords the largest water supply, and is the only river which is continually flowing into the lake. It drains a very large area of the southern highlands of Abyssinia. The River Kibish, which enters the lake at the N.E. corner, probably flows except during exceptionally dry seasons, when, as in 1911 after a dry period, the water was sinking into the sand before reaching the lake (Gwynn, 1911, p. 113). The River Kerio, which flows into the lake at the south end, is probably dry except during heavy rains (von Höhnel, 1894, vol. ii, p. 228). The Turkwell River, which after the Omo drains the largest area, rises on Mt. Elgon to the S.W., and follows a course of about 250 miles to enter the lake at a point about one-third the way up the west shore. Though it is always flowing in considerable volume at Cacheliba (150 miles from the lake) it never flows into the lake except during the rainy seasons. The mouth was, in fact, so blocked with sand in March 1931 as to be unrecognizable. There must, however, be a continual underground seepage into the lake of large amounts of water.

As in the case of the other Rift Valley lakes there is here also evidence of a former much higher water-level. Dr. Worthington discovered a beach on the slopes of Mt. Longendoti on the east shore at a height of about 500 feet above the lake. During a journey down the gorge leading from Lokitaung to the east shore (near the northern end) through the southern foot-hills of Mt. Laburr I found cliffs from 50–80 feet high, composed entirely of water-worn pebbles cemented together by some calcareous substance. The top of these must have been about 500 feet above the lake. The sides of this gorge showed many signs of water erosion at quite high levels, which indicate a previous very much higher rainfall in that district than now occurs.* The

* For the facilities which made possible a visit to this gorge and to the lake shore below it I am indebted to Mr. P. W. Harris, Assistant District Commissioner at Lokitaung.

presence of Nile fish in Lake Rudolf proves that at one time it flowed over to the north into the Nile basin.

The lake has, therefore, sunk in level by at least 500 feet, and, since it is situated in the lowest part of the Eastern Rift, there seems no reason to suppose that it lies in anything but a closed basin. The actual contraction in volume must have been very much greater than that which has occurred in the Naivasha–Nakuru or Baringo basins. It is therefore surprising that the alkalinity of the water is not even higher than it is (0·02 N.). But, as was pointed out by Gregory (1925, p. 178), the northern end of the Kenya Rift is surrounded mainly by metamorphic rocks which would yield less soda than those bounding the more southerly portion of the valley, which are mostly volcanic. So far as we know, there have been no highly alkaline springs discovered in the Rudolf basin.

Evidence of comparatively recent small fluctuations in lake-level was found by von Höhnel (1894, vol. ii, p. 159) in 1888, in the half-submerged dead trees near the mouth of the Omo, and by us in the water marks showing on a small rocky island south of Central Island, the highest of which was at a level of 50 feet above the lake.

Large aquatic vegetation.

It appears that Lake Rudolf is practically devoid of large aquatic vegetation. No water-plants of any description were found by us along the open, sandy, west shore. In two places only did we find submerged water-weed—one in Ferguson's Gulf under the lee of the spit (*Potamogeton* sp.), and the other under the lee of another sand-spit on the east shore at the foot of Mt. Longendoti (*Potamogeton* sp.). It would appear then that, if the peculiar composition of the water is a factor preventing the growth of water-weeds, it is not the only factor responsible. Shifting sand may also prevent them from gaining a footing, since the two examples discovered were living in protected situations.

It is probable that *Papyrus* and other large aquatic vegetation would have been found at the mouth of the River Omo, but the main lake was apparently devoid of these plants.

The water of the open lake.

From the total analysis given in Table XV it can be seen that, compared with Lake Baringo, there is a much larger increase of chlorine than of CO_3. This may be due in part to the precipitation of $CaCO_3$ at the higher pH of Lake Rudolf. The calcium content is, in fact, about one-fourth that of Lake Baringo.

That considerable deposition of calcium carbonate is in progress at the present time was shown by the calcareous deposits on the dry bed of the River Kaliokwell close to the lake.

At a distance of about 2 miles from the lake shore, a little south of the River Kaliokwell, Mr. Fuchs (geologist to the expedition) discovered extensive deposits very rich in calcium carbonate and containing shells of the Nile

oyster (*Aetheria elliptica*) not at present living in the lake. It is possible that, when the lake extended back to the present position of these deposits, its alkalinity was lower and its pH was in the region of 9·0. At this pH, calcium is first thrown down in large quantities. This would account for the formation of the deposits, and the water at that time would have been a favourable environment for Mollusca, owing to the high concentration of easily available calcium carbonate for the formation of their shells.

From a number of surface-samples taken from opposite Mt. Laburr in the north to a point opposite the mouth of the River Turkwell the alkalinity varied between 0·0194 and 0·0216 N. (in March 1931).

The following figures are typical of a number of determinations made on surface-samples taken from between the end of Ferguson's spit and Central Island in March 1931 :—

Alkalinity ..	0·0194 (near Central I.)–0·0210 N (near Ferguson's spit.
pH	About 9·5.
P_2O_5	1·60–1·65 mg. per litre.
SiO_2	4·0–5·0 „ „

As might be expected, there was an increase of alkalinity of the surface-waters from the centre to the edge of the lake. There was a still greater increase in the water of Ferguson's Bay (see next section).

The phosphate content was even higher than that of Lake Baringo. Here also the absence of submerged water-weed may be responsible for the greater accumulation of phosphate compared with Lake Naivasha where weed is abundant and phosphate low.

The silicate content was about one-third that of Lake Baringo and about one-fourth that of Lake Naivasha.

Observations on the diurnal changes at different depths in the deep water (48 metres) off Central Island (Station 263) were made on 2 and 3 April 1931. The results are recorded in text-fig. 5. There was a stiff S.E. breeze from 6.30 p.m. to 3.30 a.m. and from 6 a.m. to 12 midday. This was probably mainly responsible for the irregularity of the curves shown in text-fig. 5. Such conditions, however, were certainly typical of the whole period spent on Lake Rudolf, and the curves show how great was the degree of mixing even in the deepest waters. The peculiar fall of over 2° C. in the temperature of the bottom water between dawn and midday can only be ascribed to the movement of deep-water currents. The relatively high oxygen content of the lower water also illustrates the fact that a great amount of mixing was taking place. There is therefore no advantage to be gained in discussing these results further, since little is known of the factors involved. They suffice, however, to show that there must have been some circulation of water throughout the whole depth.

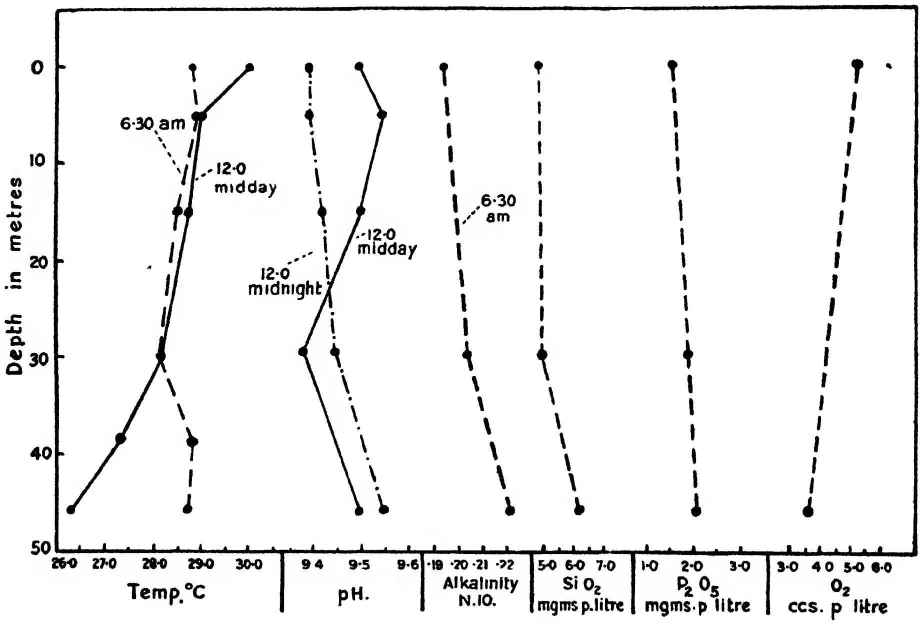
The nature and abundance of the plankton of the deep water (Station 263) is shown in Table VIII (1). The numbers indicate the density of the phyto-

plankton in the upper $2\frac{1}{2}$ metres. From counts of samples from different depths it was found that there was a rapid diminution in the phytoplankton below $2\frac{1}{2}$ metres. In the case of *Botryococcus*, less than 10 per litre were to be found below this and none below 30 metres. *Hormidium*, however, decreased less rapidly and a few were found below 30 metres.

The phytoplankton consisted entirely of Chlorophyceae, both diatoms and Cyanophyceae being absent. The possible significance of this will be discussed in the next section.

Of the zooplankton the most abundant species was the cup-shaped ciliate protozoon (not yet identified) not found in any other lake. *Diaptomus* was the most numerous of the Crustacea, though a number of other species were present in small numbers (see Table VIII (1)).

Text-fig. 5.



The effects of increasing alkalinity on the plankton.

Analyses and plankton counts were made at five stations (Table VIII (1) to (5)). These form a series of waters of increasing alkalinity, from that of the open lake water (1) (0·0194 N.) to that of two pools cut off from the lake and fast evaporating—one in the bed of the River Kaliokwell (4) (0·108 N.) and the other at the end of Ferguson's spit (5) (0·113 N.). The waters of the north and south ends of Ferguson's Gulf ((2) and (3)) were intermediate in their alkalinity. The water of these five stations was merely lake-water in different stages of evaporation. There is no reason to suppose that any water or salts reached them from other sources.

TABLE VIII.

	St. no.	Date.	Alk. N.	pH (indy.).	CO_2, turnover c.cm. per litre.	P_2O_5, mg. per litre.	SiO_2, mg. per litre.	Cyanophyceae (*Arthrospira*.)	(*Anaboenopsis Arthrospira*.)	(*Phormidium*.)	Chlorophyceae. (*Hormidium*.)	(*Botryococcus*.)	Diatoms. (*Cyclotella*, *Rhopalodia*.)	Zooplankton.
(1) Deep water . . .	263	2. iv. 31.	0·0194	9·5	5·6	1·64	5·0	nil	nil	nil	90 per litre	30	nil	*Diaptomus* (many). *Cyclops*, *Moina*, *Diapanosoma*, *Ceriodaphnia*, *Caudina* (few). Protozoa (v. many).
(2) Ferguson Gf., N. end	250	28. iii. 31.	0·0211	9·7	7·2	2·0	7·5	nil	nil	360	100	nil	<10	Young Cladocera (many). Rotifers (few). Protozoa (v. few).
(3) Ferguson Gf., S. end	247	28. iii. 31.	0·0230	$>10·0$	—	2·3	trace	nil	nil	300	10	nil	nil	Ostracods (v. many). Rotifers (v. many).
(4) Pool in estuary.	257 (*a*)	8. iv. 31.	0·108	$>10·0$	22·8	1·90	—	—	290×10^6	nil	nil	nil	nil	Rotifers (few).
(5) Pool in spit . .	257 (*b*)	30. iii. 31.	0·113	$>10·0$	28·2	2·53	—	550×10^6	nil	nil	nil	nil	nil	nil
(6) Crater A	271	3. iv. 31.	0·061	9·5	—	0·36	—	nil	nil	nil	nil	nil	<10	*Cyclops* (few). Cladocera (few). Rotifers (few).
(7) Crater B	269	3. iv. 31.	0·178	$>10·0$	—	—	—	160×10^5	nil	nil	nil	nil	nil	Rotifers (few).
(8) Crater C	273	4. iv. 31.	0·113	$>10·0$	—	—	—	250×10^5	nil	nil	nil	nil	nil	Rotifers (few).

There was a considerable increase of pH accompanying the increase of alkalinity. Table VIII shows that there was also a corresponding increase of phosphate. This was presumably due to the relative shallowness of the water of the gulf and of the two pools. The phosphate-rich bottom deposits would be stirred up to a greater extent than would those in deeper water.

The silicate content of this series showed a progressive diminution from 5 mg. per litre in the open water (Station 263) to a trace at the south end of Ferguson's Gulf (Station 247).* There was, however, a sudden rise to 7·5 mg. per litre at the entrance to the gulf (Station 250).

The phytoplankton of the waters of the series showed very striking progressive changes. Diatoms were absent from all except the north end of the gulf (Station 250), where a very few *Cyclotella* and *Rhopalodia* were found. *Melosira*, the diatom commonly found in Lakes Naivasha and Baringo, was absent. The Chlorophyceae (*Hormidium* and *Botryococcus*) were relatively abundant in the open lake water. *Phormidium* (Cyanophyceae) was found only in the gulf. *Hormidium* decreased rapidly from the north to the south end of the gulf, and *Botryococcus* was absent from the gulf. The phytoplankton of the alkaline pool (4) consisted of *Anaboenopsis* and *Arthrospira* (Cyanophyceae); pool (5) contained only *Arthrospira*, which was present in enormous numbers (550 million per litre).

The zooplankton of the open lake, as already stated, comprised a large number of Crustacea and ciliate Protozoa (Table VIII). In Ferguson's Gulf these animals largely gave place to rotifers and ostracods. In the two alkaline pools no zooplankton was found.

The amount of carbon dioxide assimilated between dawn and midday was calculated from titrations with standard acid to the phenol-phthalein and methyl-orange end points at dawn and midday. The days chosen for this work were cloudless. The figures obtained are therefore comparable. The results from four stations are given in Table VIII as c.cm. CO_2 per litre. It is obvious that the higher alkalinity of (4) and (5) made possible the existence of a much denser phytoplankton than was found in (1) and (2), by virtue of the much larger quantity of available CO_2 present, which is a necessary consequence of a higher alkalinity. As shown by the daily consumption of carbon dioxide, the intensity of photosynthesis in the open lake water (1) was only one-fifth that of the alkaline pool (5).

The Crater Lakes of Central Island.

Central Island is a volcano which has probably become extinct at a comparatively recent date. Active sulphur jets are still to be found on its eastern slopes. About seven craters can be distinguished, whose walls are composed of lava and volcanic ash. Three of these have coalesced and become filled

* Determinations made on two samples from between the north and south ends of the Gulf (not given in Table VIII) gave a silicate content of 2·5 and 1·5 mg. per litre.

with water to form Crater Lake A (Station 271). Two other lakes B (Station 269) and C (Station 273) are formed from single craters.

Crater Lake A is separated from the main lake on its west side by a low wall about 20 feet above the level of the latter. Crater Lake C is separated from the lake by a still lower wall (on its south side) which is about 5 feet above the level of the main lake.

Both these lakes must therefore have been connected with the main lake in very recent times, since marks found on a small island S.E. of Central Island showed that the main lake had recently been 50 feet above its present level.

This is further confirmed by the fact that the above-mentioned walls were flattened down as if by water-action, while the higher wall which separated crater B from the lake (200 ft. above the main lake) still maintained the form of the steep side of a volcanic crater.

Crater Lake B has therefore been unconnected with the lake for a far longer period than has A or C. It may, perhaps, never have been connected.

A glance at the total analysis of the main lake water and that of Crater Lake A given in Table XV will show that the latter was not merely evaporated lake water. The proportions of certain ions had become altered. For instance, the sodium content of the crater lake was 2·75 times, while the magnesium content was nine times that of the main lake. This is surprising in view of the fact that the alkalinity of the crater lake was three times that of the main lake. The calcium, however, was increased almost as much as the sodium content (2·6 times). The explanation is presumably to be found in the fact that, owing to the scarcity of phytoplankton in the crater lake (see below), the pH was not higher than that of the main lake (9·5).

Crater Lake A had, therefore, received salts, particularly those of Mg and K, from some source within the crater.

No total analysis was made on water from Crater Lake C. But its alkalinity (0·113 N.) was considerably higher than that of A (0·061 N.), in spite of the fact that it was connected with the lake at a more recent date than was the latter (the separating wall was lower). There must, therefore, have been a supply of soda from within this crater also.

Table VIII shows that the phytoplankton of Crater Lake A was very scarce, and comprised a very few unicellular diatoms. But the more alkaline waters of lakes B and C supported vast numbers of the blue-green alga *Arthrospira platensis*. There seems no obvious factor to which the scarcity of phytoplankton in A might be attributed, unless it were the concentration of magnesium (36 mg. per litre), which is abnormally high for natural waters other than the sea. Lake Tanganyika, however, which apparently supports a rich phytoplankton of diatoms and Cyanophyceae (West, 1907), was found to contain an equally high concentration of magnesium (38 mg. per litre: Stappers, 1914). It may be that Crater Lake A had just reached the high limit of alkalinity for the growth of diatoms and Chlorophyceae, and for Cyanophyceae other than *Arthrospira*, and had not yet attained the lowest limit of alkalinity suitable to *Arthrospira*.

It is certain that no phytoplankton other than *Arthrospira* was ever found in waters having an alkalinity above 0·023 N., and that no *Arthrospira* was ever found in waters of a lower alkalinity than 0·084 N. The alkalinity of Crater Lake A (0·061 N.) was between these two figures.

The zooplankton of Crater Lake A comprised copepods, Cladocera, and rotifers in very small numbers, but *Diaptomus*, which was present in large numbers in the main lake, was absent. In fact, the total plankton was scarcer than that of any other lake investigated. Lakes B and C were typical of very alkaline waters, in that the zooplankton was scarce and consisted of rotifers only.

Crater Lake A contained a large number of fish (*Tilapia* and *Clarias*). The former species were in very poor condition, as a result, no doubt, of the scarcity of the plankton upon which they feed. *Clarias*, a scavenger, would more easily obtain a livelihood in such an environment.

Numbers of small *Tilapia* were also caught in Crater Lake C. This was the most alkaline lake (0·113 N.) in which fish of any kind were found. A species of *Tilapia* has also been found in Lake Magadi, where the water is probably of an equally high alkalinity (Woodhouse, 1912).

It is surprising that the gills of these fish can withstand continual exposure to water of this alkalinity. Mr. E. N. Willmer has examined histologically the gills of *Tilapia* taken from this lake, and of others of the same genus from the fresher waters of Lakes Naivasha and George. He has found nothing abnormal in the histological structure of the gill-filaments of the fish from very alkaline waters.

Lakes Edward and George (0° 15′ S., 30° 0′ E. (approx.); altitude 3,000 feet; surface-area of Lake Edward 700 sq. miles; surface-area of Lake George 104 sq. miles.

General.

Lake Edward is situated in the western Rift Valley and is bisected by the Congo–Uganda border. Lake George, which is connected with Lake Edward by the narrow Kazinga Channel, lies to the north-east in a short side-branch of the main Rift (see Map 3). Between this branch and the northern extension of the main valley lie the Ruwenzori Mountains, which cover an area of approximately 1,600 sq. miles and whose snow-peaks attain an altitude of over 16,000 feet. This range therefore yields a copious water-supply to the surrounding country and to the lakes.

Meteorological observations were made at Kazinga and Kitoma at the western and eastern ends of the Kazinga Channel respectively, in June and July 1931. These are summarized in Table I. Compared with the conditions on Lake Baringo, which is at the same altitude and at approximately the same latitude, it can be seen that the average air temperatures in the Lake Edward basin were slightly lower and that the average humidities were considerably higher. The proximity of the Ruwenzori Mountains, rising abruptly on the western side from the damp forests of the Semliki Valley, which are continuous with the

enormous Ituri forest of the Congo, results in a continual condensation of moisture. The country within a radius of about 50 miles is, except on rare occasions, enveloped in a slight mist.

Map 2 shows that Lake George, the Kazinga Channel, and the eastern half of Lake Edward are all relatively shallow. In Lake Edward depths of 117 metres were recorded within two miles of the western shore, from which the Congo escarpment rises abruptly to a height of over 5,000 feet above the lake.

Water supply and drainage.

Lake George receives a number of rivers from the north and north-west, all of which rise in the Ruwenzori Mountains and enter the lake through extensive papyrus swamps. Since these mountains are composed of non-volcanic rocks, the water of Lake George was comparatively fresh (conductivity 0·000207, alkalinity 0·002 N.).

The Kazinga Channel contained water of approximately the same composition as that of Lake George. At the western mouth of the Channel the composition of the water changed rapidly within a few yards to that typical of Lake Edward (conductivity 0·000884, alkalinity 0·0096 N.). During a period of six days (in June 1931) the position of this junction between the two types of water, which was also marked by a sudden change in the type of plankton, fluctuated between the mouth of the Channel and about 1 mile within Lake Edward (see later section on this junction). The conclusion to be drawn from this is that the inflow into Lakes Edward and George, the outflow from Lake Edward, and the evaporation from both were so exactly balanced that the two lakes were at the same level, and that no permanent current flowed from one to the other, though they were in continuity. Hurst (1927, pt. ii, p. 42) came to the same conclusion in 1926. The occasional shifting of the junction is presumably due to changes in the relative rainfalls in the Lake Edward and Lake George catchment-areas.

Lake Edward receives two permanent rivers from the north (Nyamgasani and Chako), which rise on the southern slopes of Ruwenzori and which are presumably of low salinity. By far the greatest water-supply is afforded by the Ruchuru River in the south, which was unfortunately not visited. But Hurst, in 1926 (loc. cit. p. 54), found that the alkalinity of the Ruchuru water (0·0172 N.) was higher than that of Lake Edward (0·0138 N.).

This river rises in the volcanic Mfumbiro Mountains to the south, some of which are still active. Lake Edward is thus continually receiving soda from volcanic regions, for which reason the alkalinity and salinity of its waters are higher than those of Lake George or the Kazinga Channel.

There is a considerable outflow from Lake Edward via the Semliki River, which flows to the north into Lake Albert, a distance of about 150 miles (Map 2). At a point about half-way between these two lakes near Beni, it flows as rapids through a steep-sided gorge about 2 miles long in the midst of dense forest. These rapids must form a barrier to the migration of fish

and crocodiles from one lake to the other, and account for the absence from Lake Edward of the Nile fish and crocodiles which are present in Lake Albert. Further evidence for this conclusion is given elsewhere (Worthington, 1932 *a*, p. 287).

Large aquatic vegetation.

Much of the shore of Lake George and of the Kazinga Channel was fringed with papyrus swamp. At the north end of the lake there was a large area of *Papyrus*, among which were also found water-lilies and submerged water-weed (*Ceratophyllum demersum*). No water-weeds were found elsewhere in Lake George. Patches of papyrus swamp were to be found on the shores of Lake Edward, which appeared to be unproductive of water-weed. From analogy with Lake Naivasha it might have been expected that Lake George (being even fresher) would have supported similar large areas of water-weed.

Surface-waters of Lakes Edward and George.

Table IX gives results of analyses of samples from the surface-waters of the two lakes. These figures are typical of a number of analyses. It will be seen that, in spite of the considerably lower alkalinity, the pH of the Lake George water was much higher at midday than was that of Lake Edward. This was due to the greater amount of phytoplankton, especially of *Microcystis*, in the former (see Table IX). The phosphate content of the Lake George water was lower than that of Lake Edward. Though the silicate content of Lake George was more than four times that of Lake Edward, the former supported only a very small quantity of diatoms compared with the latter. No Chlorophyceae were found in either lake.

The zooplankton differed mainly in the scarcity of rotifers in Lake Edward and in their abundance in Lake George. Both lakes appeared to be devoid of *Diaptomus*.

In the very large quantity of *Microcystis*, Lake George is reminiscent of Lake Baringo. They are also similar in that they are both shallow lakes, and the waters of both are slightly brown in colour even after filtration.

The effect of swamps on phosphate supply.

It has been shown that Lake Baringo received a large amount of phosphate during the wet season from the River Tiggeri. It was suspected that the presence of extensive papyrus swamps, which choke the mouths of the rivers flowing into Lake George, would have some effect upon the phosphate supplied to the lake by those rivers. To test this, phosphate determinations were made on samples taken from a river both above the swamp and at the mouth. The river chosen for this purpose was the Chambura, which flows northwards into the Kazinga Channel and which is choked with papyrus swamp from its mouth to a distance of about 1 mile upstream. As a comparison, similar samples were examined from the River Niamweru, which flows into Lake Edward from the east and is devoid of swamps (see Map 2). The results are given

TABLE IX.

Surface-samples.

	Date.	Sta. no.	Alk. N.	pH (mdy.).	P_2O_5, mg. per litre.	SiO_2, mg. per litre.	Diatoms. (*Synedra Rhopalodia*.)	Diatoms. (*Synedra, Rhopalodia, Nitzschia*.)	Cyanophyceae. (*Microcystis, Aphanocapsa*.)	Zooplankton.
L. Edward . .	9. 7. 31.	574	0·0096	8·9	0·28	4·0	nil	160 per litre	90	*Daphnia*, *Ceriodaphnia*, *Cyclops* (many). Rotifers (few).
L. George . .	22. 7. 31.	623	0·0021	9·9	0·15	18·3	10	nil	1780	*Monia*, *Ceriodaphnia* (few). *Cyclops*, Rotifers (many).

in Table X. The phosphate content of the water at the mouth of the River Chambura was lower than that of the water 3 miles upstream. In the case of the River Niamweru, there was slightly more phosphate in the water at the mouth than in that 1½ miles upstream.

It appears that the passage of the river through extensive swamps results in some way in the fixation of phosphate. The effect of the swamp was also marked by a lowering of the pH of the water at the mouth of the River Chambura.

The lower phosphate content of the surface-waters of Lake George as compared with that of the Lake Edward waters may therefore have been due to the more extensive areas of papyrus swamp in the former, which occurred particularly round the mouths of the rivers flowing in at the north end.

TABLE X.

Surface-samples.

	Date.	Alkalinity N.	pH (mdy.).	P_2O_5 (mg. per litre).
(1) River Chambura.				
3 miles from mouth	29. v. 31.	0·00094	7·7	0·67
At mouth	,,	0·00094	7·5	0·20
(2) River Niamweru.				
1½ miles from mouth ...	5. vi. 31.	0·00146	—	0·18
At mouth	,,	—	—	0·19

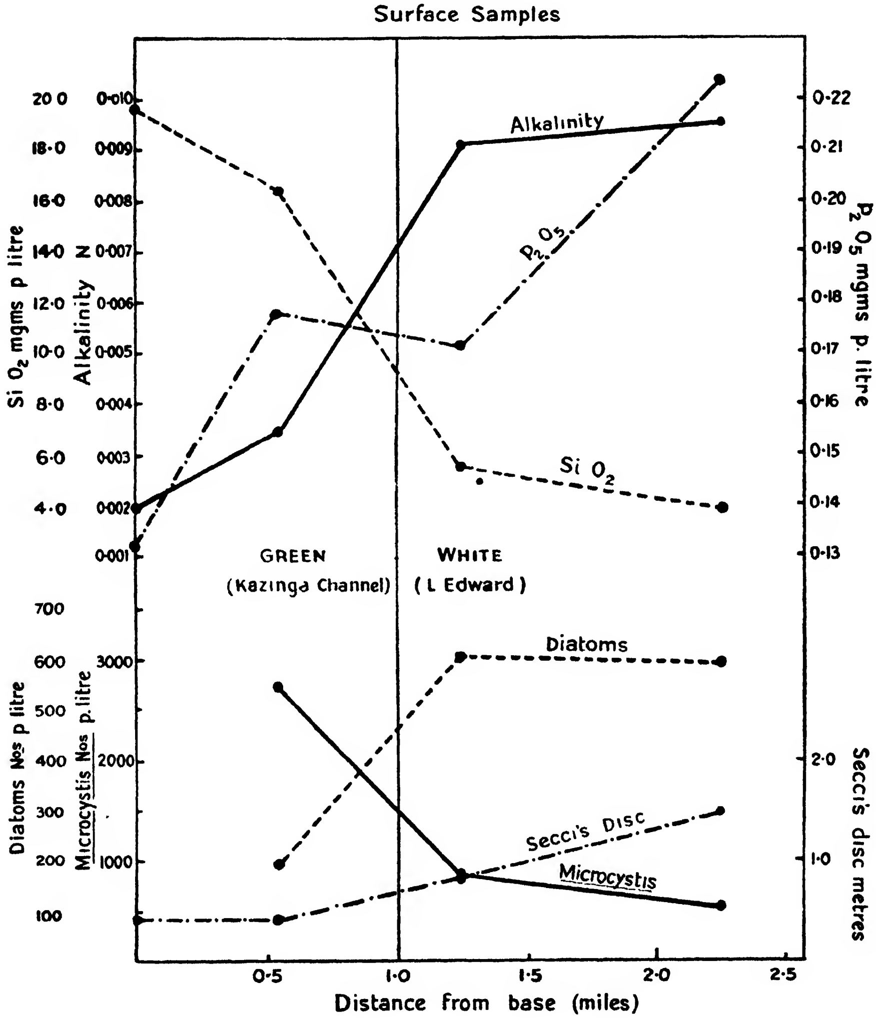
The Kazinga Channel—Lake Edward junction.

The difference between the phytoplankton content of the Kazinga Channel water and that of the waters of Lake Edward was so marked that the former appeared quite green while the latter was transparent. The point at which the two waters met was so clearly defined that it required only a few seconds for our boat (travelling about 1 mile in 10 minutes) to pass from quite green to transparent water. The position of this green-white junction changed every day. This was noted daily over a period of 6 days, and drift-bottles were placed in the mouth of the channel to determine the direction of the current. At times, when the junction had moved out into Lake Edward, there was a current flowing out of the Channel. When the junction had receded into the Channel mouth, the current was reversed. These fluctuations must have been due, as already stated, to changes in the relative levels of Lakes Edward and George consequent upon changes of rainfall.

The very striking and sudden changes across this junction both in the composition of the surface-water and in the nature of the phytoplankton (on 11. vi. 31) are illustrated by the curves in text-fig. 6. There was, within a distance of half a mile, a rise in alkalinity from 0·0033 to 0·0096 N., and a decrease in silicate content from 17·7 to 5·4 mg. per litre. The phosphate content was relatively constant across the junction, but both before and after passing the junction there was a considerable rise.

Plankton counts showed that these changes in the composition of the water were accompanied by equally sudden changes in the nature and abundance of the phytoplankton. The lower curves in text-fig. 6 show that the numbers of the blue-green alga *Microcystis* fell from 2,700 to 800 per litre, and that those

TEXT-FIG. 6.



of unicellular diatoms rose from 170 to 620 per litre within the same two-thirds of a mile. The depth at which Secci's disc disappeared at each position bore an inverse relation to the numbers of *Microcystis* present.

Judging from the sharpness of the junction between the green and white water it is probable that, had samples been taken more closely together, these curves would have been even steeper where they crossed the transition-line.

These determinations were repeated daily for four days, and the same changes were found to occur across the junction, though this was always in a different position. The results of analyses of surface-samples at various distances from the base-point, together with indications of the position of the green-white junction and of the direction of the current on these four days, are given in Table XI.

TABLE XI.

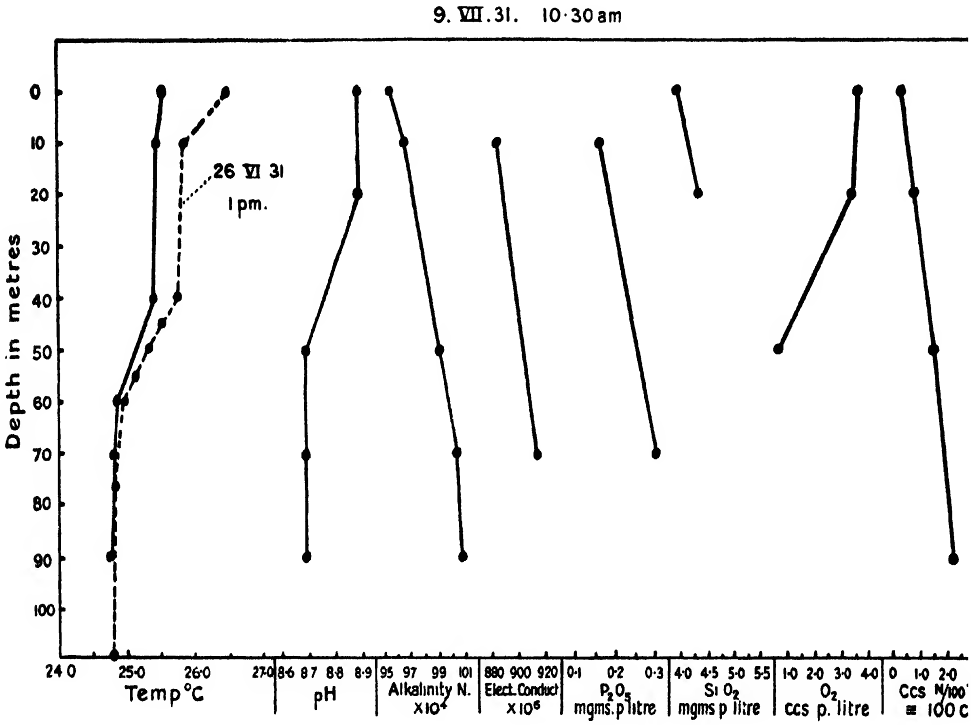
Date.	Time.		Distance from base (miles). 0.	0·2.	0·4.	0·55.	1·25.	2·25.	Direction of current.
8. vi. 31.	4 p.m.	Alk. N. ..	—	0·0026	0·0024	0·0030	0·0092	—	Out of Channel.
		SiO_2 mg. per litre.	—	14·4	12·5	11·9	8·0	—	
		P_2O_5, mg. per litre.	—	0·123	0·098	0·083	0·248	—	
				green.			white.		
9. vi. 31.	3 p.m.	Alk.	—	0·0022	0·0022	0·0065	0·0096	—	Into Channel.
				green.			white.		
10. vi. 31.	6 a.m.	Alk.	—	0·0075	0·0082	0·0083	0·0095	—	—
		SiO_2......	—	9·79	7·33	5·75	5 24	—	
		P_2O_5	—	0·076	0·085	0·120	0·148	—	
				green.			white.		
11. vi. 31.	11 a.m.	Alk.	0·0020	—	—	0·0033	0·0091	0·0096	Out of Channel.
		SiO_2	19·5	—	—	17·4	5·5	3·95	
		P_2O_5	0·132	—	—	0·178	0·171	0·225	
		Secci's disc (mts.)	0·4	—	—	0·4	0·8	1·4	
				green.			white.		

There is no doubt that there was a factor limiting the development of *Microcystis* in Lake Edward and another limiting the growth of diatoms in the Channel. From the water analyses given in Table XI there is no obvious indication of the nature of these factors. That the silicate content played no part in determining the distribution of the diatoms is evident from the fact that they were more abundant in Lake Edward, where there was a lower concentration of silicate than in the Channel. A difference between the two waters, which is, however, not indicated in the Table, was the brownish coloration of the channel water after filtration and the complete transparency of the Lake Edward water. This colour was probably due to organic substances in solution, which may have rendered the channel water a favourable environment for *Microcystis*. The water of Lake Baringo had a similar coloration and supported a large number of *Microcystis*, though it also contained a considerable quantity of the filamentous diatom *Melosira*.

The deep water of Lake Edward.

As already mentioned, a depth of 117 metres was recorded within 2 miles of the western shore of Lake Edward. A section across the lake basin is given in Map 3. It was unfortunately impossible to make a thorough survey of this deep water, owing to its great distance from our base camp at the mouth of the Kazinga Channel. Temperature measurements were made on 26. vi. 31, and on 9. vii. 31 these were repeated, and one series of water samples from different depths was examined. The results are shown in text-fig. 7.

TEXT-FIG. 7.



The two sets of temperature measurements show that the daily surface rise of temperature penetrated to a depth of about 10 metres. From 10 to 40 metres was a region of almost uniform temperature. Between 40 and 60 metres was a definite thermocline, in which the temperature dropped by about 1° C. Below this the temperature was again uniform.

The pH of the water below 50 metres (hypolimnion) was uniform at 8·7, that of the upper 20 metres (epilimnion) was higher (8·9). Diurnal variations of pH of the surface-waters were not determined.

The alkalinity increased from the surface to between 50 and 70 metres. From 70 to 90 metres there was practically no change of alkalinity. The curve of electrical conductivity of samples from 20 and 70 metres shows that there was a considerable increase of salinity below the thermocline. The higher phosphate content at 70 than at 20 metres is as would be expected.

The water above 50 metres was odourless, while samples from 50 metres and below smelt strongly of H_2S. The increasing amount of sulphide present from the surface to 90 metres is illustrated by the curve showing the amount of iodine absorbed. The figures obtained from surface and 90 metre samples correspond to 0·78 and 3·87 c.cm. H_2S per litre respectively (total sulphide expressed as H_2S).

The figures obtained for oxygen content by the unmodified Winkler method had therefore to be corrected for the presence of H_2S, which had, of course, reduced some of the iodine (see section on methods). The O_2 curve in text-fig. 7 is constructed from the corrected figures. Owing to the fact that a zero value was obtained from samples below 50 metres, it can only be said with certainty that the water below this depth contained less than 0·88 c.cm. of oxygen per litre, though in all probability the water below 60 metres was devoid of oxygen.

Owing to the production of a blue colour on the addition of ammonium molybdate to samples from 50 metres and lower (see section on methods), no estimation of the silicate content below 20 metres was made. The curve in text-fig. 7 shows that there was a considerable increase in silicate content in the first 20 metres.

The plankton of the surface-water has already been described (see Table IX). Below 60 metres no zooplankton was found, except for a considerable number of *Chaoborus* larvae. There were a few diatoms and *Microcystis* below the thermocline which were presumably dead, and, being more resistant to decay than the zooplankton, had fallen to that depth from the surface. Gill-nets set below the thermocline showed that few fish entered the hypolimnion. Two *Clarias* only were caught.

The significance of the existence of a thermocline in Lake Edward and of its absence in the other lakes investigated will be referred to in the discussion.

Lakes Bagusa and Maseche.

These are two small crater lakes within a mile of the southern shore of Lake George (Map 2). Both are nearly circular, about a quarter of a mile in diameter, and surrounded by dense bush.

Lake Bagusa was devoid of any aquatic vegetation, and the water contained no phyto- or zooplankton. The only organisms living in the water were a large number of culicine and *Eristalis* larvae (not yet identified) in the shallow water at the edge. The water itself was deep brown in colour. On acidifying, a brown precipitate was thrown down, and the water was thereby cleared. The alkalinity was very high (0·235 N.). Though odourless before treatment,

the addition of acid caused the evolution of a considerable amount of H_2S, the quantity of which is shown by the iodine absorbed by 100 c.cm. (Table XII). This figure corresponds to 5·46 mg. of H_2S, which must have been present in the form of sulphide. The colour of the water prevented the determination of pH.

TABLE XII.

Surface-samples.

	Date.	Alk. N.	pH (mdy.).	Conductivity.	c.cm. N/100 I = 100 c.cm.
Lake Bagusa	18. vii. 31.	0·235	—	—	3·20
Lake Maseche	18. vii. 31.	0·710	>10·5	0·0451	1·51
Lake George	22. vii. 31.	0·002	9·8	0·000207	0·32

Lake Maseche, on the other hand, supported a vast number of the blue-green alga *Arthrospira*. The number per litre in the sample collected was of the order of 500×10^4. No other phyto- or zooplankton was to be found. There were, however, large numbers of Ephydrid, Stratyomyid, *Erystalis*, and Culicine larvae in the shallow water at the edge. The water was clear, and the alkalinity was higher than that of any other lake visited (0·71 N.), but the sulphide content, as indicated by the iodine absorbed, was about half that of the water of Lake Bagusa (see Table XII).

Analyses of a surface-sample taken from Lake George at the mouth of the Kazinga Channel are included for comparison in Table XII. It will be seen that the amount of iodine absorbed was one-tenth that absorbed by the water of Lake Bagusa.

These results seem to indicate that the water of Lake Maseche has passed the high limit of pH for the existence of any zoo- or phytoplankton other than *Arthrospira*, while in Lake Bagusa there was some factor preventing the appearance of any form of plankton. This factor may have been the very high concentration of sulphide. The above-mentioned dipterous larvae appeared to flourish in water of extremely high alkalinity and salinity. They were never found in the fresher waters of the neighbourhood. Similar *Eristalis* larvae (but no other genera) were abundant in Lake Katwe near the north shore of Lake Edward (Map 2), the water of which is saturated with salts (chiefly sodium chloride). The collection of salt, which is continually crystallizing from Lake Katwe, is, in fact, a flourishing native industry. For some reason (perhaps secondary) a water of very high salinity is therefore a favourable environment for these larvae.

LAKE KIKORONGO.

This is a small crater lake (diameter about half a mile), similar in form to Lakes Bagusa and Maseche situated in open grassland within two miles of the western bay of Lake George (Map 2). At the time at which we visited this lake (28. vii. 31), there was a foul smell arising from it, due to a floating carpet of decaying

matter, which had been blown by winds to the western shore. The neighbourhood was infested with flies. The water itself was odourless and quite clear. The plankton consisted of large numbers of *Arthrospira* and near the shore there was in addition a considerable quantity of floating masses of a pink alga (not yet identified).

The alkalinity of the water was very high (0·408 N.) and the total salt content, as shown by the electrical conductivity (0·0346 ohms^{-1} cm.$^{-1}$), was about three-quarters that of Lake Maseche. Along the northern shore were about fifteen small springs welling up from the bottom in the shallow water at the edge. Water collected from the mouth of one of these with a pipette was of a lower alkalinity and salinity than that of the lake itself (0·386 N., 0·0335 ohms^{-1} cm.$^{-1}$). Much of the north and east shores of the lake was formed of a calcareous tufa, presumably deposited by springs.

TABLE XIII.

Analyses of Lake Kikorongo (gm. per litre).

	A. Barnes, Jan. 1920.	A. W. Groves, April 1930.
Na	1·44	11·52
K	—	2·28
CO_3	1·31	14·94
Cl.	0·67	5·15
SO_4	—	1·86

Gill-nets were set to catch fish, but with no success. The western shore, however, was littered with skeletons of recently dead *Clarias* and *Tilapia*.

The probable explanation of the occurrence of these skeletons was obtained from a native of the district. During the wet season the water of Lake George rises and flows over into Lake Kikorongo (there is no high land between them). As a result of this, some fish find their way into Lake Kikorongo, the waters of which would then be less alkaline owing to dilution with the flood water. Subsequently the water-level falls, and the two lakes are again separated. Further falling of the lake-level would result in an increase of alkalinity above that which the fish are able to withstand, and they die. Their decaying bodies become filled with gas, float on the surface, and are blown by the prevailing wind to the western shore.

That this is a yearly occurrence seems doubtful, but it is probable that the lakes became connected during the exceptionally wet season of the middle of 1930, in which case the skeletons found by us were of fish which came from Lake George at that time. The sudden inflow of fresh water from Lake George would also cause the deposition of calcareous tufa. The bottom of the lake for some 20 yards from the west shore was also formed of tufa.

When visited by Mr. R. E. Dent in 1905, Lake Kikorongo contained fish (*Tilapia*). It is therefore evident that the water was at that time less alkaline

than in July 1931. That there have been great changes in the alkalinity of the lake water during the past ten years is shown by two analyses made in January 1920 and April 1930. These are given in Table XIII.* The large increase in sodium and carbonate content shows that the water was very much less alkaline in 1920 than in 1930. We must therefore conclude either that there has been a gradual increase in alkalinity during the past fifteen years or that, when fish were observed in the lake in 1905 and when the water sample analysed in 1920 was collected, there had been a recent inflow of fresh water from Lake George.

Discussion.

Effects of increased alkalinity on composition of water.

It has already been pointed out that when a lake water becomes more alkaline by the addition of sodium carbonate there is, besides an increase of salinity and pH, a decrease in the concentration of certain ions in solution, particularly those of calcium and magnesium, which are of possible biological significance. It is known that, on increasing the pH of a solution containing Ca and Mg, a large amount of Ca is precipitated at about pH 9·0 and of Mg at about pH 10·5. The pH of the majority of the waters investigated attains a value of over 9·0, and many of over 10·5. The pH of the water of Lake Hannington was over 10·5. In spite of this, as the total analysis in Table XV shows, as much as 26 mg. per litre of Ca were present in solution. The lowest calcium content found was 5 mg. per litre (in Lake Rudolf). The magnesium content was in most cases low (2–7 mg. per litre), and in Lake Hannington only a trace was found. In the water of Crater Lake A (Lake Rudolf) the magnesium content was exceptionally high (36 mg. per litre), but the pH (9·5) had not reached the critical point for the precipitation of Mg (10·5). It was found by Irving (1926) that, on increasing the pH beyond 10·5 by the addition of sodium carbonate to sea-water, no more calcium was precipitated, owing to the relatively high solubility of the hydroxide which was produced at that pH. It is probable then that, even in the most alkaline of these waters, there is a certain amount of calcium in solution not less than 5 mg. per litre, as found in Lake Rudolf. A soft natural water, such as that of Loch Lomond in Scotland, contains about 4 mg. per litre of calcium and only a trace of magnesium.

We can conclude that the reduction in concentration of calcium and magnesium in these highly alkaline lakes is not sufficiently great to constitute a biologically limiting factor.

Measurements of the silicate content of the waters of these lakes showed that there was an apparent decrease of silicate with an increase of alkalinity. It would, however, be expected that an increase of alkalinity would result in an increase of silicate in solution. So far as is known, no work has been

* For permission to reproduce these figures I am indebted to Mr. E. J. Wayland, Director, Uganda Geological Survey.

done on the validity of silicate measurements by the molybdate method on waters of high alkalinity, but it seems probable that the addition of acid, which is a necessary part of the procedure, would reduce the proportion of silica present as silicate in solution, with the possible production of colloidal SiO_2. In this case the amount of silicate present would be higher than the analysis showed. The scarcity of diatoms in Lake Rudolf cannot be attributed to the low silicate content (4–5 mg. per litre), which, though low compared with that of Lake Naivasha, is still about twenty times that of sea-water (Table XIV). It cannot be considered that silicate content is ever a limiting factor for diatom growth in these lakes.

Evidence for biologically limiting factors.

In Table XIV are drawn up a series of figures obtained from surface-samples of ten of the lakes visited by the expedition, together with a rough indication of the nature and abundance of the plankton. They are arranged in order of increasing salinity (as shown by the electrical conductivity). Figures for sea-water and Cambridge tap-water (a hard water) are also included for comparison.

It will be seen that two lakes only have a lower salinity than that of Cambridge tap-water, and that the salinity of one is higher than that of sea-water. Only two have a lower alkalinity than that of the tap-water, and all except one have a higher alkalinity than that of sea-water.

In considering the nature of the phytoplankton in these lakes (Table XIV) we see that no algae other than *Arthrospira* and *Anaboenopsis* (Cyanophyceae) were ever found in waters more alkaline than 0·08 N., and that no other algae were found in water as alkaline as this. So far as is known, *Arthrospira* has never been recorded from any but highly alkaline waters, and it is reasonable to conclude that it is the high alkalinity, whereby it is able to assimilate large quantities of CO_2 (see Table VIII), which determines its occurrence. There is, however, as yet, no conclusive evidence that a high salinity may not also be a favourable factor. The scarcity of phytoplankton in Crater Lake A may be attributable as already suggested (section on Lake Rudolf) to the fact that the alkalinity and salinity of the water are intermediate between the upper limit for all algae (except *Arthrospira*) and the lower limit for *Arthrospira*. These limits are suggested by the results from other lakes, and are in general supported by the results of Miss Jenkin's Expedition in 1929. Lake Nakuru (alkalinity 0·296 N.) contained *Spirulina laxissima* and *Anaboena spiroides* (Cyanophyceae), in addition to *Arthrospira* (Rich, 1932).

The occurrence of vast quantities of *Microcystis* in Lakes George and Baringo, and of little or none in Lakes Naivasha and Rudolf, is difficult to explain. It has, however, been suggested by Pearsall (1921) from work on English lakes that the Cyanophyceae are typical of waters of relatively high organic content. Both Lake George and Baringo were very shallow (less than 8 metres), and their waters were coloured brown even after filtration. This coloration was probably

TABLE XIV.

Lake.	Conductivity, $\times 10^6$.	Alkalinity N.	pH (midday).	P_2O_5 (mg. per litre).	SiO_2 (mg. per litre).	Phytoplankton.	Zooplankton.
George	207	0·002	9·9	0·15	18·3	*Microcystis* × × ×	Cladocera, Copepods (no *Diaptomus*).
Naivasha ..	264	0·003	9·0	nil–0·09	20·0	Diatoms × × × Chlorophyceae × Cyanophyceae ×	Cladocera, Copepods (no *Diaptomus*).
Baringo	—	0·005	8·8	1·28	15·8	*Microcystis* × × × Diatoms × ×	Cladocera, Copepods.
Edward	884	0·010	9·0	0·28	4·0	Diatoms × *Microcystis* ×	Cladocera, Copepods (no *Diaptomus*).
Rudolf (open water).	2860	0·020	9·5	1·64	4·2	Chlorophyceae × ×	Cladocera, Copepods, Protozoa (ciliate).
Crater Lake A.	7150	0·060	9·5	0·36	—	nil	Cladocera, Copepods.
Naivasha Crater Lake.	—	0·080	·10·0	0·81	—	*Arthrospira* × × ×	Copepods (*Diaptomus* only).
Kikorongo .	34600	0·408	—	—	—	*Arthrospira* × ×	nil.
Hannington.	35700	0·160	—	1·73	—	*Arthrospira* × × ×	Rotifers.
Maseche ...	45100	0·710	>10·5	—	—	*Arthrospira* × × ×	nil.
Channel sea-water.	41200	0·0023	8·3	0·01–0·006	0·20–0·24	—	—
Cambridge tap-water.	417	0·004	7·7	—	8·0–10·0	—	—

due to some organic matter in solution derived from the mud, which, in shallow water, would be stirred up by winds. The water of Lakes Naivasha and Rudolf was quite clear. It is possible, then, that a water of high organic content is the most favourable environment for the growth of the blue-green algae *Microcystis* and *Aphanocapsa*, and that under such conditions they can multiply sufficiently to cause a 'water bloom,' such as was found in Lakes Baringo and George. It would appear also from the evidence at hand that such waters, in which this coloration was found, were not a favourable environment for the Chlorophyceae.

The phosphate content of the water, except that of Lake Naivasha, did not approach a figure low enough to limit the growth of phytoplankton (Table XIV). It was shown in the section on Lake Naivasha that the period at which the phosphate content of the water was apparently zero was one during which there was an enormous growth of water-weed, and that the phytoplankton was then probably at a maximum. It was suggested that the growth of these plants had resulted in the consumption of the phosphate. At a later date the weeds and phytoplankton had considerably decreased and phosphate was detectable in the water. Lake Naivasha was certainly the only lake visited in which there was a prolific growth of water-weeds. It might be suggested that this weed limits the phosphate content of the water, both by direct consumption of P_2O_5 and by virtue of the fact that it protects the bottom deposits of the shallow water, which are rich in phosphates and would otherwise be disturbed by winds.

No zooplankton other than rotifers was ever found in waters more alkaline than 0·08 N. (Naivasha Crater Lake). In this lake *Diaptomus* only was found. The pH of the water at midday reached a value of over 10·0. In waters of a lower alkalinity than this the pH did not reach 10·0. In these waters many species of Crustacea were found, and no reason can be suggested for the occurrence or absence of any particular species. In waters of an alkalinity exceeding 0·1 N. no zooplankton was found other than rotifers. No zooplankton of any kind was found in Lake Maseche, the alkalinity of which was 0·710 N. and the pH at midday exceeded 10·5. It is again impossible to decide how far the salinity of the water is a factor in limiting the occurrence of these animals, but Lakes Kikorongo and Hannington are of possible interest in this connection (Table XIV). It can be seen that the salinity (electrical conductivity) of Lake Hannington is greater than that of Kikorongo, but that its alkalinity is much less. This must be due to a higher proportion of salts other than carbonates in Lake Hannington. The water of Lake Hannington supported rotifers, whereas no zooplankton was found in Lake Kikorongo. This suggests that it was the (probably) higher pH of the Lake Kikorongo water which prevented the occurrence of rotifers, and that salinity as high as that of Lake Hannington is not a limiting factor. pH measurements were unfortunately not made on the waters of these two lakes.

TABLE XV.

Analyses by Government Chemist. London (mg. per litre).

	L. Naivasha.	L. Baringo.	L. Rudolf.	Crater Lake A.	L. Hannington.	L. Nakuru.
Sp. gr.	1·00024	1·00044	1·00190	1·00530	1·03910	1·01383
Na	41·0	126·0	770·0	2114·0	14360·0	5550·0
K	19·0	15·0	23·0	118·0	304·0	256·0
Ca	16·0	22·0	5·0	13·0	26·0	10·0
Mg	7·0	2·0	4·0	36·0	trace	nil
Fe and Al	6·0	36·0	3·0	trace	trace	6·0
CO_3	90·0	168·0	652·0	1700·0	17650·0	6150·0
Cl	10·0	36·0	429·0	1300·0	3450·0	1375·0
SO_4	17·0	40·0	56·0	46·0	204·0	253·0
NO_3 and NO_2	nil	trace	trace	—	—	trace
Li	nil	nil	nil	nil	nil	nil
Date of collection	10. xii. 30.	7. xii. 30.	13. i. 31.	4. iv. 31.	4. ii. 31.	9. xii. 30.

No fish other than *Clarias* and *Tilapia* were found in water of an alkalinity greater than 0·02 N. The crater lakes of Central Island (Lake Rudolf) were interesting in that, though they had obviously been quite recently connected with the main lake, none of the numerous fish living in the latter were to be found in them other than *Clarias* and *Tilapia*. In Crater Lake A (alkalinity 0·06 N., max. pH 9·5) both *Clarias* and *Tilapia* were found. In Crater Lake C (alkalinity 0·113 N., max. pH probably over 10·5 *) only *Tilapia* were living. The pH of lake A was not higher than the midday pH of the main lake, and it is therefore surprising that none of the other lake fish were to be found in it. The higher salinity of lake A may have prevented them from living there. It seems therefore that *Clarias*, and to a greater extent *Tilapia*, is able to live in water of very high salinity and alkalinity. Their resistance to these conditions is apparently greater than that of any other of the numerous genera of fish living in Lake Rudolf. This fact may have some bearing upon the present distribution of African fish, since during very dry periods, such as have been known to occur in the past history of East Africa, some lakes may have been concentrated by evaporation to a condition fatal to all fish other than *Tilapia*, which would have survived to recolonize a new lake formed during a subsequent wet period. It is certain that *Tilapia* is among the most widely distributed of African fishes. The water of Lake Kikorongo, to which fish have occasional access, is either too alkaline or of too high a salinity for *Tilapia* to withstand (section on Lake Kikorongo).

Layering of the lake waters.

It was evident from measurements of temperature and analyses of water at different depths that, except in Lake Edward and the Naivasha Crater Lake, there was no evidence of layering of the water.† There was no trace of a thermocline, and the analyses showed that there was probably considerable mixing of the water at different depths.

Ruttner (1931), in a study of a large number of lakes in Java, Sumatra, and Bali, found that in small lakes of a surface-area of 1–2 sq. km. steep thermoclines were to be found at depths of 2–8 metres. In larger lakes layering of the water was less evident, owing, he suggests, to the greater effect of winds on a larger area of water. In certain cases he was able to observe a change from a condition in which there was complete circulation of the waters to one in which a thermocline was developed. This change he attributed to a calm period following a period of heavy winds. In Lake Toba, the largest lake investigated (1000 sq. km.), he found that there was a thermocline of a more gentle gradient at a depth of 25 to 70 metres (Ruttner, 1931, p. 375).

It was unfortunate that, except in the case of the Naivasha Crater Lake,

* C contained a large phytoplankton, in A there was practically no plant-life (Table VIII).

† Lake Naivasha, Station 30, in November 1930, is another possible exception (p. 173).

no examination was made of any but the surface-waters of lakes comparable in area with the smallest lakes investigated by Ruttner. Though no temperature measurements were made, it was evident from the analyses that there was very marked layering of the water of the Naivasha Crater Lake. This, as already suggested, was probably due not only to the absence of wind mixing but also to the seepage of water of high salinity from the base of the crater.

The absence of water-layering in the larger lakes, such as Naivasha, Baringo, and Rudolf, is probably due to the heavy winds which are prevalent in the Great Rift Valley.

The temperature curves given in text-fig. 7 show that there was a thermocline in the deep waters of Lake Edward from 40 to 70 metres, which was therefore comparable with that found by Ruttner in Lake Toba. It will also be seen that the upper limit of this thermocline did not mark the lower limit of the daily heating and cooling from above, which did not penetrate to a greater depth than 10 metres. As has been already suggested (Worthington and Beadle, 1932), this deep thermocline was possibly not a ‘temperature’ thermocline, but a ‘salt’ thermocline. It may have been produced by the entrance into the lake of water of a higher salinity than that of the surface-water, which, owing to its greater density, would have remained at the bottom, and would not have circulated with the upper layers. It will be remembered that the water of the River Ruchuru flowing into Lake Edward from the south was in 1926 of a higher alkalinity than that of the surface-water of the lake (Hurst, 1927). It is not improbable, in view of the volcanic nature of the surrounding country, that water of high salinity is flowing into the lake from other sources.

The thermocline recorded by Ruttner in Lake Toba may also be of this nature. It is interesting to note that certain springs flowing into Lake Toba were of a higher salinity than that of the surface lake-water (Ruttner, 1931, pp. 382–8).

Summary.

(1) The lakes visited by the expedition are situated on the floor of the Great Rift Valley.

(2) Owing to the prevalence of soda springs and to the high soda content of the volcanic lavas, of which the country is largely composed, these lakes are all relatively alkaline. Their alkalinity is due mainly to sodium carbonate.

(3) The high alkalinity of the water is due in some cases (e.g. Lake Rudolf) mainly to evaporation from a previously much greater volume. In others (e.g. Lake Edward) the inflow of water of high soda content is chiefly responsible.

(4) Some fifteen lakes were visited, of which the least alkaline was Lake George in Uganda (alkalinity 0·002 N., midday pH 9·9) and the most alkaline Lake Maseche in Uganda (alkalinity 0·71 N., midday pH over 10·5).

(5) The relatively low alkalinity of the waters of Lakes Naivasha and Baringo is probably due to the existence of underground outlets.

(6) The reduction in concentration of calcium and magnesium due to the high alkalinity is not sufficiently great to constitute a biologically limiting factor.

(7) Neither the silicate nor the phosphate content of these waters was sufficiently low to limit the life of phytoplankton. A possible exception was the water of Lake Naivasha in which the phosphate content was at one period very low.

(8) *Phytoplankton.*

(*a*) *Arthrospira* (Cyanophyceae) was found only in waters of an alkalinity greater than 0·06 N. In the most alkaline lakes they were present in sufficient numbers to make the water bright green in colour.

(*b*) Other algae were found only in waters of an alkalinity of 0·06 N. and less.

(*c*) There was some evidence that waters of a high organic content were a favourable environment for *Microcystis* and *Aphanocapsa* (Cyanophyceae).

(9) *Zooplankton.*

No zooplankton other than rotifers was found in waters of a higher alkalinity than 0·1 N. Certain rotifers can withstand water of very high alkalinity and salinity.

(10) Certain fish, particularly *Tilapia*, are able to live in water of an alkalinity and salinity apparently toxic to the majority of fish living in these lakes (alk. 0·1 N).

(11) It is not certain whether the high pH or the high salinity is the more important factor limiting the fauna and flora in very alkaline lakes.

(12) The absence of layering of the waters in the majority of lakes investigated was attributed to the prevalence of heavy winds in the Rift Valley. It is suggested that the layering of the deep waters of Lake Edward, which was accompanied by a thermocline at 40 to 70 metres, was due to the presence of a layer of water of high salinity underlying a layer of less dense water.

References.

Atkins, W. R. G. 1923. The Phosphate Content of Fresh and Salt Waters in its Relationship to the Growth of the Algal Plankton. J. Mar. Biol. Assoc. xiii, no. 1, pp. 119–50.

——. 1926. The Phosphate Content of Sea Water in relation to the Growth of the Algal Plankton.—Part III. J. Mar. Biol. Assoc. xiv, no. 1, p. 447.

Beadle, L. C. 1932. Scientific Results of the Cambridge Expedition to the East African Lakes, 1930–1.—3. Observations on the Bionomics of some East African Swamps. J. Linn. Soc., Zool. xxxviii, no. 258, p. 135.

Carter, G. S., & Beadle, L. C. 1930. Journ. Linn. Soc., Zool. xxxvii, no. 251, p. 205.

Clark, W. M. 1928*a*. Determination of Hydrogen Ions. Baltimore.

——. 1928*b*. Colour Chart of Indicators. Baltimore.

Clarke, F. W. 1924. Data of Geochemistry. U.S. Geol. Survey Bull. 5th edition.

Gregory, J. W. 1921. Rift Valleys and Geology of East Africa. London.

Gwynn, C. W. 1911. A Journey in Southern Abyssinia. Geogr. Journ. xxxviii, pp. 113–39.

VON HÖHNEL, L. 1894. Discovery of Lakes Rudolf and Stephanie. 2 vols. (transl. from German). London.

HURST, H. E. 1927. The Lake Plateau Basin of the Nile. Egyptian Govt. Publication, Cairo.

IRVING, L. 1926. The Precipitation of Calcium and Magnesium from Sea Water. J. Mar. Biol. Assoc. xiv, pp. 441–67.

——. 1929. Biology of Lakes in Kenya. 'Nature,' cxxiv, p. 574.

JENKIN, P. M. 1932 *a*. Reports on the Percy Sladen Expedition to some Rift Valley Lakes in Kenya in 1929.—I. Introductory Account of the Biological Survey of Five Freshwater and Alkaline Lakes. Ann. & Mag. Nat. Hist. (10) ix, p. 533.

——. 1932 *b*. Unpublished. Seen in MS.

LEAKEY, L. S. B. 1931 *a*. East African Lakes. Geogr. Journ. lxxvii, no. 6, p. 497.

——. 1931 *b*. The Stone Age Cultures of Kenya. Cambridge.

MARSHALL, S. M., & ORR, A. P. 1928. The Photosynthesis of Diatom Cultures in the Sea. J. Mar. Biol. Assoc. xv, pp. 321–64.

PEARSALL, W. H. 1921. The Development of Vegetation in the English Lakes, considered in relation to the Evolution of Glacial Lakes and Rock Basins. Proc. Roy. Soc. London, B, xcii, p. 259.

POWELL-COTTON, P. H. G. 1904. A Journey through Northern Uganda. Geogr. Journ. xxiv. pp. 56–65.

RICH, F. 1932. Reports on the Percy Sladen Expedition to some Rift Valley Lakes in Kenya in 1929.—IV. Phytoplankton from the Rift Valley Lakes in Kenya. Ann. & Mag. Nat. Hist. (10) x, p. 233.

RUTTNER, F. 1931. Hydrographische und Hydrochemische Beobachtungen auf Java, Sumatra und Bali. Archiv f. Hydrobiol., Suppl. 8, ii.

SAUNDERS, J. T. 1923. The Measurement of the Carbon Dioxide Output of Fresh-water Animals by means of Indicators. Proc. Camb. Phil. Soc. (Biol. Sci.) i, pp. 43–8.

THIENEMANN, A. 1931. Tropische Seen und Seetypenlehre. Archiv f. Hydrobiol., Suppl. Bd. ix. 2, pp. 205–31.

TRESH, J. C., & BEALE, J. F. 1925. Examination of Water and Water Supplies. London.

WAYLAND, E. J. 1931. Summary of Progress of the Geological Survey of Uganda for the Years 1919–25. Entebbe, Uganda.

WEST, G. S. 1907. Report on the Fresh-water Algae, including Phytoplankton of the Third Tanganyika Expedition. J. Linn. Soc., Bot. xxxviii, pp. 81–197.

WOODHOUSE, C. W. 1912. J. E. African Nat. Hist. Soc. ii, p. 95.

WORTHINGTON, E. B. 1930. Observations on the Temperature, Hydrogen-ion Concentration, and other Physical Conditions of the Victoria and Albert Nyanzas. Internat. Rev. d. ges. Hydrobiol. u. Hydrogr. Bd. xxiv, pp. 328–57.

——. 1932 *a*. The Lakes of Kenya and Uganda. Geogr. Journ. lxxix, no. 4, p. 275–97.

——. 1932 *b*. Scientific Results of the Cambridge Expedition to the East African Lakes, 1930–1.—1. General Introduction and Station List. J. Linn. Soc., Zool. xxxviii, no. 258, p. 99.

——. 1932 *c*. Ditto.—2. Fishes other than Cichlidae. J. Linn. Soc., Zool. xxxviii. no. 258, p. 121.

WORTHINGTON, E. B., & BEADLE, L. C. 1932. Letter to 'Nature,' cxxix. pp. 55–6.

Scientific results of the Cambridge Expedition to the East African Lakes, 1930–1.—5. Reptiles and Amphibians. By H. W. Parker, B.A.

(With 10 Text-figures)

The collections of reptiles and amphibians made by Dr. Worthington and his colleagues fall readily into two groups, those from the zoologically well-known areas of Uganda and Kenya (Lakes Bunyoni, Edward, George, Kijanebalola, Nabugabo, Nakavali, Baringo, Hannington, Naivasha, and Mt. Kenya) and those from the almost unknown Lake Rudolf region. In the first group the most noteworthy features are the really high proportion of species hitherto very incompletely known and the surprising discovery of two well-marked new species of snakes, one of them venomous and probably dangerous to man. The Lake Rudolf collection is most interesting, however, not from any superabundance of new and rare forms (though both are present), but from the light which it sheds on the relationships of the herpetological fauna of the region. From its geographical position between Kenya, Uganda, and the Anglo-Egyptian Sudan one might expect the fauna to be essentially a Sudan-Kenya composite. But although many of the species are known to occur both in Kenya and the Sudan, the facies of the fauna is essentially that of the Somaliland sub-province. Every single species, except those endemic in the region, has been also recorded from Somaliland, whereas many are unknown elsewhere in Kenya or in the Sudan. The endemic forms, too, are more closely allied to Somali species than to any others ; the two new races described below are both local forms of species either confined to Somaliland (*Philochortus*) or scarcely known outside it (*Agama*).

In a recent discussion of the herpetology of British Somaliland (Parker, 1932) the author, in attempting an analysis of the fauna arranged the species in four groups, and application of the same principles to the Lake Rudolf collections gives the following results :—

I. ' Eremian ' species, i. e. those found in Africa north of about the 10th parallel (north), Arabia, or both and not extending S.E. into Kenya :—

(1) *Lygodactylus picturatus gutturalis.*
(2) *Echis carinatus.*

II. Species found all over Africa, except perhaps the Rain Forest, and sometimes extending into Arabia :—

(1) *Crocodilus niloticus.*
(2) *Trionyx triunguis.*
(3) *Hemidactylus brooki.*
(4) *Mabuya brevicollis.*
(5) *Naja nigricollis.*
(6) *Rana mascareniensis.*
(7) *Bufo regularis.*

III. 'Savannah' species, i.e. those found in East Africa south of about the 10th parallel (north), rarely extending further north in the Sudan or Arabia :—

(1) *Eremias spekii sextaeniata.*
(2) *Latastia longicaudata revoili.*
(3) *Varanus ocellatus.*
(4) *Lygosoma sundevallii.*
(5) *Psammophis biseriatus.*
(6) *Rhamphiophis rostratus.*
(7) *Rana delalandii.*
(8) *Chiromantis petersi.*

IV. Species endemic in the Somaliland region, sometimes extending into Kenya :—

(1) *Hemidactylus isolepis.*
(2) *Agama rueppelli occidentalis.*
(3) *Philochortus intermedius rudolfensis.*
(4) *Leptotyphlops fiechteri.*
(5) *Coluber smithi.*

Comparison of this grouping with the similar tables for Somaliland (op. cit. p. 337) shows a lower proportion of endemic species (23 per cent. compared with 45 per cent.), fewer Eremian forms, and many more in group II. There also appears to be less tendency for the species of group III to form local races ; in Somaliland nearly a third of the Savannah species are modified to form distinct endemic races, but none of these are yet known to extend into the Rudolf region.

In the same paper it is suggested that the principal factor in the development of the specialized Somaliland fauna is the aridity of the climate, and a rainfall chart is given showing a mean annual rainfall in the Somali peninsula of less than 20 inches, whereas the neighbouring countries to the west and south have 40 inches or more. According to that chart the Lake Rudolf area has a relatively high annual precipitation and the present discovery of a typical Somaliland fauna in the region would appear to invalidate the hypothesis previously put forward. But the probability seems to be rather that the chart is wrong, and that Lake Rudolf lies in an isolated patch of country with a very low rainfall, comparable with Somaliland. Unfortunately, no continuous records are available, but there seems to be unanimity of opinion amongst those who know the region that it is very arid ; Dr. Worthington (1932, p. 281) speaks of there being 'practically no rainfall', and assures me that the average is certainly less than 20 inches annually. It seems very probable, therefore, that the conclusions to be drawn from a study of the present collection strengthen, instead of weaken, the probability of correlation between climate and faunal change in north-east Africa.

In the following discussions of the various species, the place-names are those used in the general account of the expedition and may be found in the maps illustrating Dr. Worthington's paper earlier in this volume. Acknowledgments are due not only to Dr. Worthington and all members of the expedition for the meticulously careful way in which the material was preserved and labelled, but to the authorities of the Museum of Comparative Zoology, Harvard, the United States National Museum, and the California Academy of Sciences for the loan of much valuable comparative material.

(1) XENOPUS LAEVIS (Daudin).

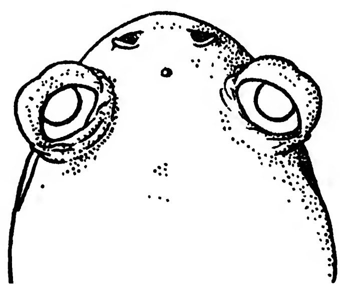
♂, 2 ♀♀. Lake Naivasha.

43 ♂♂ ♀♀, hgr. and yg. Lake Bunyoni.

The specimens from Lake Naivasha are normal *X. laevis*, but the Lake Bunyoni series is so very different that at first sight it seems as though this lake harbours a definite race. A number of differences from the normal can be detected, thus :—

(*a*) Size :—The largest specimen collected measures only 41 mm. from snout to vent, and Dr. Worthington reports that, although the frogs occur in thousands, no larger examples were seen. Normal adults of *X. laevis* measure at least 50 mm., usually much more.

TEXT-FIG. 1.



Xenopus laevis (Daudin).
Specimen from Lake Bunyoni, showing pathological eyelids.

(*b*) Colour :—All the specimens, except one, are exceedingly dark in colour and the lower surfaces are heavily spotted and dotted with black.

(*c*) The eyes are very large and prominent, the head apparently slightly broader, and the snout shorter than in specimens from other localities (text-fig. 1).

Loveridge (1932, p. 114) considers these differences to indicate that the *Xenopus* of Lake Bunyoni is at least racially distinct; but it seems quite probable that they may have a biological rather than a taxonomic significance. Considering the most noticeable size-difference first, two factors

must be borne in mind. Firstly, very few of the specimens are sexually mature; only three females have ripe pigmented ova and well-developed oviducts. These three examples measure 34, 39, and 39 mm., but other larger females measuring 40 and 41 mm. are not sexually mature. Thus it is doubtful whether any fully adult specimens have yet been captured, for the only mature examples have apparently only just reached maturity. In the second place, Worthington reports that the frogs in Bunyoni lead a pelagic existence and are plankton feeders. They possess no special adaptation for microphagy, and it is not improbable that, compelled by circumstances to subsist on prey it is ill-equipped to catch, the *Xenopus* population of Lake Bunyoni is dwarfed through malnutrition.

The differences grouped together as (*b*) and (*c*) above may have a single common cause, for the very large prominent eyes are pathological. The tissues of the lower eyelid of every specimen examined are literally packed with encysted metacercariae of an Echinostomid fluke.* The pressure set up by this heavy infection has forced the eyes outwards (text-fig. 1), and it is very probable that this pressure, operative during the early post-larval period, has materially affected the development of the whole head. In addition, it has not improbably affected the vision, either by direct inflammation of the visual apparatus or mechanically by injury to the lower eyelid, which is so much thickened as to appear opaque and non-retractile; in preserved specimens it covers the lower half of the eye completely. It has been shown experimentally that eyeless examples of *Xenopus* are much darker than the normal when kept under the same conditions (Hogben and Slome, 1931, p. 13) and very dark immature normal specimens are usually found to have liberally dark-spotted lower surfaces.

Further collecting alone can decide whether these suppositions are correct and whether the heavy parasitic infection is normal or epidemic.

(2) Rana galamensis Dum. & Bibr.

Hgr. Lake Nakavali.

(3) Rana fuscigula Dum. & Bibr.

♀. Lake Bunyoni.

(4) Rana delalandii (Dum. & Bibr.).

Hgr. ♂. Mouth of Kaliokwell River, Lake Rudolf.

(5) Rana mascareniensis Dum. & Bibr.

Juv. Mouth of Kaliokwel River, Lake Rudolf.

(6) Phrynobatrachus natalensis (A. Smith).

Juv. Stream running into Lake Hannington.

* I am indebted to my colleague Dr. Baylis for determining the family to which these flukes belong; should further identification prove possible, he will probably publish a note on the parasite.

(7) PHRYNOBATRACHUS KINANGOPENSIS (Angel).

Phrynobatrachus acridoides (non Cope), Andersson, 1911, Kungl. Svensk. Vet.-Ak. Handl. xlvii, 6, p. 28.

Arthroleptis rouxi (non Nieden), Angel, 1925, Voy. Alluaud et Jeannel Afr. Or., Rept. & Batr. p. 50.

Phrynobatrachus kinangopensis (Angel), Loveridge, 1929, Bull. U.S. Nat. Mus. cli, p. 105.

3 ♂♂, 1♀. 11,000 ft., Mt. Kenya (coll. L. C. Beadle).

As indicated above, no two authors have hitherto agreed as to the name to be applied to the *Phrynobatrachus* of Mt. Kenya. Andersson, indeed, realized that his specimens differed in several ways from *P. acridoides* (Cope), but ascribed these differences to individual variations. Angel, with specimens from the Aberdare Mts. and Mt. Kenya before him, concluded that the two were specifically distinct, described the former as a new species *kinangopensis*, and referred the latter to *P. rouxi* (Nieden). Loveridge (1925) identified *rouxi* (originally described from the west side of Lake Victoria) with the West African *P. ogoensis* (Boulenger) and later referred frogs from Mt. Kenya and other localities in Kenya Colony to *kinangopensis*. Comparison of seven specimens from Mt. Kenya (including three of the series reported upon by Andersson) with nine topotypes of *kinangopensis* has convinced the writer that the two are probably conspecific. This form is distinguishable from *P. acridoides* (Cope) (topotypes examined) by its smaller size, indistinct tympanum, shorter digital webbing (text-figs. 2 & 3), and slightly shorter hind limbs, a series of characters too marked and constant to be other than of specific, or at least racial, importance. If Angel is correct in identifying the Mt. Kenya frog with Nieden's *rouxi*, then the name *kinangopensis* must give way to this; but if Loveridge is also correct, *rouxi* is a synonym of *ogoensis*. Comparison of the accompanying text-figures will, however, make it apparent that neither of these suggestions is probable, for, unless Nieden's figure is grossly inaccurate, *rouxi* differs from all the others in having the fifth toe markedly longer than the third, instead of the converse. *P. kinangopensis* is also, apparently, quite distinct from *P. ogoensis*, and appears to be a valid form confined to the Kenya highlands.

(8) CHIROMANTIS PETERSI Boulenger.

♂. Sukh Plains, Lake Rudolf.

It is not possible to say definitely whether this single specimen should be referred to the typical form or to the ill-defined larger Somaliland race (*kelleri*); it appears to be full-grown, but measures only 54 mm. from snout to vent, and the interorbital space is slightly narrower than the upper eyelid, thus resembling, rather, the typical form.

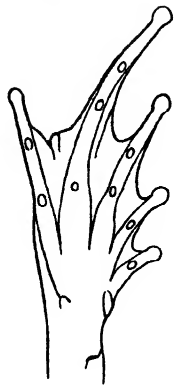
(9) HYPEROLIUS CINCTIVENTRIS Cope.

♂. Lake Bunyoni.

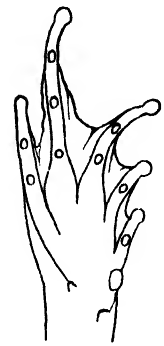
(10) HYPEROLIUS PICTURATUS Peters.

♀. Lake George.

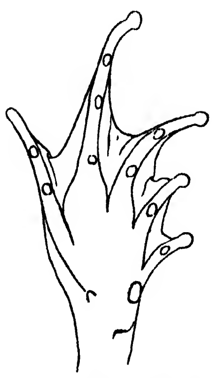
Text-fig. 2.



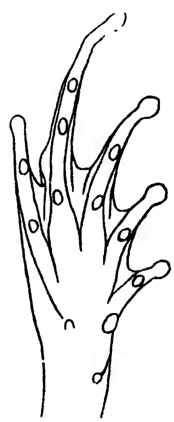
Text-fig. 3.



Text-fig. 4.



Text-fig. 5



Text-fig. 6.

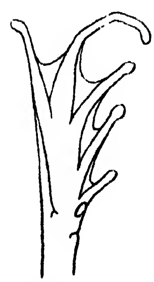


Fig. 2.—*Phrynobatrachus acridoides* (Cope). Topotype male. Right foot.
Fig. 3.—*Phrynobatrachus kinangopensis* (Angel). Topotype male. Right foot.
Fig. 4.—*Phrynobatrachus kinangopensis* (Angel). Mt. Kenya male. Right foot.
Fig. 5.—*Phrynobatrachus ogoensis* (Boulenger). Type male. Right foot.
Fig. 6.—*Phrynobatrachus rouxi* (Nieden). Type (after Nieden). Right foot.

(11) HYPEROLIUS STRIOLATUS Peters.

♀. Lake Kijanebalola.

(12) ? HYPEROLIUS STUHLMANNI Ahl.

♂. East shore of Lake Edward.

This determination and the status of the species are both open to doubt; but if, as seems probable from the locality, the specimen is conspecific with the single female (?) described by Ahl, the following additional note on the colour may be useful. The dark dorsal vermiculations are much larger than those figured in 'Das Tierreich, Anura,' iii, fig. 271, and approach the condition of the variegated form of *H. taeniatus* Peters; on the back there are a few small orange-tipped warts, and the concealed surfaces of the limbs are pink with orange-red spots; smaller spots of this colour are sparsely scattered all over the venter, flanks, and chin.

(13) BUFO VITTATUS Boulenger.

Hgr. ♀. Lake Nabugabo.

(14) BUFO REGULARIS Reuss.

Juv., 3 tadpoles. Lake Baringo.
2 ♀♀. Mouth of Kaliokwell River, Lake Rudolf.
Hgr. Near Mt. El Moitat, east shore of Lake Rudolf.
♂. West shore of Lake Rudolf.

(15) LEPTOTYPHLOPS FIECHTERI (Scortecci).

♀. Mouth of Kaliokwell River, Lake Rudolf.

At the present time our knowledge of the snakes of the genus *Leptotyphlops* is in a very unsatisfactory condition. The present example is a small, hook-snouted form which agrees very closely with the description of *fiechteri*, known hitherto only from Italian Somaliland. The ratio of diameter to length is somewhat higher than in the type (79·5 *vice* 68·5) and the tail is relatively shorter (14·5 *vice* 12·5), but in other respects there is very close agreement.

(16) CHLOROPHIS HETEROLEPIDOTUS (Günther).

♂, v. 181, c. 127+1. Katunguru, Kazinga Channel, Lake Edward.

(17) CHLOROPHIS IRREGULARIS (Leach).

♀, v. 164, c. 101+1. Lake George.

(18) COLUBER SMITHI (Boulenger).

Juv. ♀, Sc. 21, v. 193, c. 93+1. Lokitaung, Northern Turkana Plains, Lake Rudolf.

This specimen differs from the published descriptions of the species in having the preocular separated from the frontal, the latter shield as long as the parietals, a rather higher number of ventrals, and a characteristic colour-pattern. But another specimen in the British Museum from 'West of the Juba River', collected by Donaldson Smith in 1895 (Boulenger, 1896, p. 216), is in some ways intermediate; the preocular and frontal are separated, but the propor-

tions of the other head-shields and colour are almost exactly as in the type, whilst the number of ventrals is lower, 171. The separation of the frontal and preocular cannot be regarded as of specific importance, for in the male co-type they only just make contact, whilst the colour-pattern exhibited by the present example is probably the juvenile livery, which becomes obscure with age. There is a series of narrow black transverse bars on the mid-dorsal zone, a series of similar smaller vertical bars on the flanks alternating with the dorsal series and a ventro-lateral row of black spots alternating with the laterals ; a broad black bar across the nape, another on the occiput, and a third, less distinct, between the eyes and extending downwards on to the upper lip.

In several respects these southern examples of *C. smithi* resemble the western *C. tchadensis* (Chabanaud).

(19) Coluber keniensis, sp. n.

Holotype a juvenile ♂ from Lake Baringo, collected by E. B. Worthington ; Brit. Mus. no. 1932.5.2.7.

Snout long, obtuse. Rostral once and a half as broad as high, the portion visible from above measuring one-fourth its distance from the frontal ; internasals about as long as broad, shorter than the prefrontals ; frontal broader than the supra-ocular, once and a third as long as broad, a little longer than its distance from the end of the snout, and two-thirds the length of the parietals ; loreal quadrangular, once and a half as long as deep ; one preocular, in contact with the frontal, with two suboculars below it, and a third scale separating the fourth upper labial from the preocular and loreal ; nine upper labials, the fourth and fifth entering the eye ; two postoculars ; temporals 2+3 ; four lower labials in contact with the anterior chin-shields ; posterior chin-shields widely separated, about as long as the anterior.

Scales smooth, in 25 rows ; ventrals obtusely angulate laterally, 204 ; anal entire ; subcaudals 104.

Grey-brown above, with 10 longitudinal series of quincuncially arranged, small, black spots on the anterior half of the body ; posterior half of body and tail immaculate ; black spots on each supra-ocular, beneath the eye, and on the temple ; a narrow transverse bar behind the parietals ; white beneath, immaculate except anteriorly, where the lowermost rows of the black spots of the flanks lie on the outer ends of the ventrals.

Length 265 mm. ; tail 66 mm.

This form appears to be most closely allied to *florulentus*, but is distinguished by the possession of more scales round the body, two suboculars, and an undivided anal shield.

(20) Dasypeltis scaber (Linn.).

♂, Sc. 24, v. 210, c. 71+1. Lake George.

♀, Sc. 25, v. 223, c. 52+1. Lake Naivasha.

The first-mentioned is a uniformly brown-coloured specimen of the '*palmarum*' variety and the latter a melanistic example.

(21) PSAMMOPHIS BISERIATUS Peters.

♀, juv. v. 150, 148, c. 117+1, 110+1. Near the Mouth of Kaliokwell River, Lake Rudolf.

(22) RHAMPHIOPHIS ROSTRATUS Peters.

♀, hgr. ♀, v. 180, 164, c. 94+n, 115+1. Mouth of Kaliokwell River, Lake Rudolf.

As Loveridge (in press) has pointed out, the writer was in error in proposing a new specific name for the W. African *Rhamphiophis,* though correct in regarding it as specifically distinct from the E. African form. These two specimens are normal *rostratus,* although the caudal count is higher than hitherto recorded.

(23) NAJA MELANOLEUCA Hallowell.

Head. Katunguru, Kazinga Channel, Lake Edward.

(24) NAJA NIGRICOLLIS Reinhardt.

♂, Sc. 25/25, v. 202, C. ? Mouth of Kaliokwell River, Lake Rudolf.

(25) ECHIS CARINATUS (Schneid.).

♂, Sc. 28, v. 163, c. 33+1. Mouth of Kaliokwell River, Lake Rudolf.

(26) BITIS WORTHINGTONI, sp. n.

Holotype a ♂, no. 1932.5.2.8 in the British Museum, from the shore of Lake Naivasha ; collected by E. B. Worthington.

Nostrils directed outwards, in a single nasal, which touches the rostral and the first upper labial. (Indications of a suture on the dorsal margin in front of the nostril suggest that this condition is brought about by the fusion of a rostro-nasal scale with the nasal.) Rostral small, about once and a half as broad as deep ; head covered with small, imbricate, strongly keeled scales, 12 across the vertex from eye to eye : a compressed, erect, spine-like scale above each eye, measuring two-thirds the horizontal diameter of the eye ; two series of scales between the eye and the labials ; 18–19 scales round the eye ; two scales between the supranasals anteriorly ; 11–13 upper labials ; 5 lower labials in contact with the chin-shields. Scales in 27 rows at mid-body, all strongly keeled ; ventrals 136 ; anal entire ; subcaudals 28, entire, except the 7th and 26th, which are divided and abnormal in having two shields on the right corresponding to one on the left.

Grey-brown above, with a light yellow dorso-lateral stripe on each side on the 7th to 9th scale-rows ; bordering this light stripe above and below are a series of black semi-lunar spots, sometimes light-centred, of which the upper series are the larger and may correspond to, or alternate with, the lower. Head lighter, the dorsal dark zone of the back continuing forwards on to the occiput to form a very regular, black, narrowly light-edged arrow-head ; a small black spot behind each supraciliary spine ; upper and lower labials black, white-blotched. Belly whitish, heavily mottled and stippled with black ; tail uniform yellow beneath.

Total length 275 mm.; tail 33 mm.

This very distinct new species is akin in several ways to *B. atropos* (Linn.) and to *B. caudalis* (Smith), but differs from any known species of *Bitis* in having the nasal in contact with the rostral, and single subcaudals. These differences would, at first sight, appear to indicate that the species ought to be referred to some other genus, possibly a new one, for they are just the characters normally used to differentiate the various genera of the Viperinae. Too much stress, however, should not be placed on these two points. The subcaudal condition, for example, is very variable in some other vipers, particularly in *Trimerseurus monticola* Günther, where all may be divided or all entire, and even within the genus *Bitis* some variation is found; females of *B. caudalis* have the normal subcaudals replaced by small keeled scales. The nasal condition may have even less significance, for, as indicated above, there may be anomalous fusion of two or more shields, and in all other ways the nostril, situated in an excavated nasal with a crescentic supranasal above it, is similar to that of all the known species of *Bitis*.

But the best indication of generic relationship is furnished by the presence of a supranasal sac, a character not hitherto recorded, but present in all the seven species of the genus examined as well as in the new form. This sac is a semi-lunar pocket, lying immediately under the supranasal scute and almost coincident with it in size and shape.

Superficially it appears as if the supranasal scute, instead of being in juxtaposition to the nasal, as is usual in the majority of snakes, imbricates it. But, although this may have been the origin of the cavity, the fact that it persists in *Pseudocerastes*, a derivative of *Bitis* in which the supranasal is wanting, suggests that it may have a deeper significance.

The cavity is lined by a horny cuticle which is continuous with the external cuticular layer and appears to be shed with it at sloughing, and microtome sections of the head of an embryo *Bitis arietans* fail to show any modification of the epidermis which would suggest that the pit has any sensory function. The dorsal side of the cavity, that is to say, the under surface of the supranasal shield, is lined by an epithelium similar to that of the lower surfaces of the other head-scales; it is regularly beset with projecting hemispherical cells which give it a minutely granular appearance in surface-view. The lining of the ventral side of the sac, the portion of the nasal scale which is not visible from outside, differs, however, from the upper surfaces of the other head-scales in having only a very thin, not corrugated epidermis and a very delicate cuticle. No specialised nerve-endings were seen, but dissection of an adult Puff-adder's head showed that the sac receives a number of branches from the ophthalmic branch of the fifth cranial nerve, the nerve which supplies the region of the nostril.

The sac is best developed in *B. nasicornis*, where it extends under the nasal horn and is only narrowly separated from its fellow of the opposite side; it is also present and well developed in *B. gabonicus*, *B. atropos*, *B. arietans*,

B. inornata, *B. cornuta*, *B. caudalis*, and *Pseudocerastes persicus*. An invagination in the nasal region of a viper at once suggests the possibility of relationship with the pit of the Crotalinae and it is not impossible that the two are homologous. No very definite evidence can be brought forward in support of such a view except the general situation between nostril and eye, a general similarity between the lining membranes of the two (West, 1900, pp. 49–59, pl. iv.) and the fact that the Crotaline pit, though not connected with the nostril, is also partly innervated by the ophthalmic branch of the trigeminal nerve. A comparison of the early developmental stages of both may produce evidence for or against this hypothesis.

(27) HEMIDACTYLUS ISOLEPIS Boulenger.

4 ♂♂, 5 ♀♀, 1 egg. Mouth of Kaliokwell River, Lake Rudolf.

This series shows a degree of variation not hitherto recorded. The head is never twice as long as broad (as it appears to be in the type), the subdigital lamellae of the thumb vary from 5 to 6, of the fourth finger from 7 to 8, of the inner toe from 5 to 7, and of the fourth toe from 7 to 10; the most frequent combination is 5, 7, 5, 8. The upper and lower labials vary from 7 to 8 and 5 to 7 respectively, there may be only one pair of large chin-shields, and the femoral pores vary from 6 to 8, the lesser number being the commoner. The number of scales about the middle of the body appears to vary with the sex; in males there are about 62 to 65 and in females from 67 to 77.

The egg, which contained a nearly mature embryo, is of the usual oval, hard-shelled, geckonid type, and measures about 7×5 mm.

(28) HEMIDACTYLUS BROOKII Gray.

Hgr. ♀. Mouth of Kaliokwell River, Lake Rudolf.

(29) LYGODACTYLUS PICTURATUS GUTTURALIS Bucage.

♀. Lake Baringo.

Juv. Turkana Plains, near Nepal Pass, Lake Rudolf.

(30) AGAMA RUEPPELLI Vaillant.

The five specimens collected by the expedition at the mouth of the Kaliokwell River, Lake Rudolf, differ markedly from typical examples of *A. rueppelli*, but comparison with examples from various localities in Kenya shows a more or less complete gradational series, and suggests that we are dealing with a single variable species. The Kenya specimens have previously been referred to *A. vaillanti* Boulenger, but this name is probably (Parker, 1932) a strict synonym of *A. rueppelli*. The available material can be divided into three groups, corresponding with three geographical areas, and characterized by differently proportioned heads and larger or smaller scales. These differences are sufficiently obvious when specimens are compared, but not easily expressed in words, for there are some complications. One of the standard methods of indicating scale-size is to give the number of scales round the middle of the body, but in the present instance increased scale-size is accompanied by a

stouter habitus, so that the mid-body scale-count is approximately the same for all the groups. Another method is to give the number of scales on the vertebral line between the insertion of the fore and hind limbs; this can be done with some degree of success, but as the dorsal scales are arranged in oblique series convergent towards the vertebral line, a more accurate method is to count the scales in a standard length of an oblique series. A complication which makes itself apparent in this method is that proportions change with growth, although the actual number of scales remains constant; consequently, the scale-counts obtained in this way are only comparable for individuals of approximately the same size. The variation in the shape of the head can be conveniently measured by a comparison of the length from the tip of the snout to the anterior border of the ear with the maximum width. The three recognizable forms are :—

(*a*) AGAMA RUEPPELLI RUEPPELLI Vaillant.

Agama rueppelli Vaillant in Revoil, Miss. Pays Çomalis, Rept. & Batr. p. 6, pl. i. (1882).

Agama vaillanti Boulenger, Ann. Mus. Civ. Genova, (2) xv, 1895, p. 12.

The distance from the tip of the snout to the anterior border of the ear is less than the maximum width of the head. The scales on the vertebral line vary from 22 to 29, and there are no enlarged dorso-lateral scales. The number of scales in an oblique series of the standard length (tip of snout to ear) varies in juveniles from 9 to 12, and in adults from 10 to 8.

Distribution.—British Somaliland, northern Italian Somaliland, and the Ogaden district of Ethiopia.

Specimens examined :—

Snout to vent.	Sex.	Vertebral scales.	Oblique scales.	Locality.
mm.				
24	juv.	25	12	Dagah Shabell.
29	,,	27	12	10° 32′ N., 48° 59′ E.
39	,,	27	11	Goolis Mts.
41	,,	29	11	Sol Haud.
43	,,	27	10	Goolis Mts.
46	,,	?	9	Zeila.
48	,,	29	12	Ania, Ethiopia.
49	,,	26	10	10° 42′ N., 49° E.
58	♂	26	10	Buran Distr.
63	♂	22	9	10° 42′ N., 49° E.
63	♀	26	10	Beretableh.
70	♂	25	8	10° 27′ N., 49° E.
71	♂	26	9	Berbera.
75	♀	24	8	Haud.
75	♀	29	9	Webi Shebeli.
77	♂	29	10	Sassabana, Ethiopia.
81	♀	?	8	Beretableh.
84	♀	28	8	Dagah Shabell.
86	♀	23	8	10° 32′ N., 48° 59′ E.
102	♂	26	8	'Somaliland'; cotype.

(*b*) AGAMA RUEPPELLI SEPTENTRIONALIS, subsp. n.

Agama vaillanti (*non* Boulenger) Lönnberg, Svenska Vet.-Ak. Handl. xlvii, 6, 1911, p. 6; Loveridge, Proc. Zool. Soc. London, 1920, p. 142; id. Bull. U.S. Nat. Mus. cli, 1929, p. 57 (in part).

The distance from the tip of the snout to the anterior border of the ear is equal to the maximum width of the head. There are 30–35 scales on the vertebral line, and some of the dorso-laterals may be enlarged (Lönnberg, 1911, p. 11). The number of scales in an oblique series of the standard length varies from 14 in half-grown specimens to 10 or 12 in adults. Colour as in the typical form.

Distribution.—Central and southern Kenya.

Specimens examined:—

mm.						
62	♂	35	14	Mbunji, Kenya.	M. C. Z. 18280.	
77	♀	34	10	Voi, Kenya.	M. C. Z. 18281.	
78	♀	33	12	Kenya Colony.	U.S. N. M. 49059.	Cotypes.
78	?	32	12	Madagos, Kenya.	C. A. S. 66032.	
88	♀	31	10	Mt. Njero, Kenya.	U.S. N. M. 66901.	
90	♀	33	12	Kenya Colony.	M. C. Z. 29640.	

(*c*) AGAMA RUEPPELLI OCCIDENTALIS, subsp. n.

Agama vaillanti (*non* Boulenger) Loveridge, Bull. U.S. Nat. Mus. cli, 1929, p. 57 (in part).

In juvenile specimens the head is similar to that of the preceding race, but in adults the distance from snout to ear is longer than the maximum width. There are 36–38 scales on the vertebral line and some dorso-laterals may be slightly enlarged; the number of scales in an oblique series of the standard length is 19–20 in juveniles and 15–17 in adults. The colour-pattern of immature specimens is similar to that of the typical form, but the adult is uniform light grey with a few small white dots on the sides.

Distribution.—Lake Rudolf and the country between Kenya Colony and Ethiopia.

Specimens examined:—

mm.						
47	juv.	37	20	Mouth of the Kaliokwell River, Lake Rudolf.	B.M. 1932.5.2.1.	
51	,,	36	19	,, ,,	B.M. 1932.5.2.2.	
55	,,	36	17	,, ,,	B.M. 1932.5.2.3.	Cotypes.
76	♂	38	16	,, ,,	B.M. 1932.5.2.4.	
95	♀	37	15	,, ,,	B.M. 1932.5.2.5.	
97	♀	38	16	Between Kenya Colony and Ethiopia.	U.S. N. M. 66927.	

(31) VARANUS OCELLATUS Rüppel.

Juv. ♂. Sukh Plains, near Kachel, Lake Rudolf.

(32) EREMIAS SPEKII SEXTAENIATA Stejneger.

♂. Turkana Plains, near Nepal Pass, Lake Rudolf.

(33) PHILOCHORTUS INTERMEDIUS RUDOLFENSIS, subsp. n.

Holotype a ♂, no. 1932.5.2.6 in the British Museum, from near the mouth of the Kaliokwell River, Lake Rudolf; collected by E. B. Worthington.

Head a little depressed, about once and two-thirds as long as broad, its depth equal to the distance between the centre of the eye and the tympanum. Snout pointed, with rounded canthus rostralis. Hind limb reaching to half-way between the fore limb and the ear; foot once and a half as long as the head. Nostril separated from the first upper labial and the postnasal by a narrow rim; prefrontals separated by a median granule; frontal as long as its distance from the tip of the snout, once and a half as long as broad; parietals once and a third as long as broad; interparietal rhomboidal, once and two-thirds as long as broad, separated from the occipital by a group of three granules; four supraoculars, the fourth broken up into four scales; five supraciliaries, separated from the second and third supraoculars by a row of granules. Rostral not entering the nostril; a single postnasal; anterior loreal shorter than the second; five upper labials anterior to the subocular; a long narrow temporal along almost the whole outer margin of the parietal.

Scales feebly keeled posteriorly, smooth anteriorly; two median rows largest; 32 dorsals and laterals across the middle of the body; 14 enlarged, feebly keeled scales between the hind limbs. Ventrals in 6 longitudinal and 28 transverse series; 20 gular scales in a longitudinal median series; 7 plates in the collar; caudal scales strongly keeled, 22 in the fourth whorl; 10 femoral pores on each side, 27 lamellae beneath the fourth toe.

Colour as in the typical form.

Dimensions.—End of snout to vent 46 mm.; length of head 10; width of head 6; depth of head 5; fore limb 15; hind limb 29; foot 15; tail 130.

The status of this form is very difficult to assess on the basis of a single specimen, but there are so many features in which it differs from the average of the normal form of *P. intermedius* from Somaliland that it is difficult to avoid regarding it as at least racially distinct. The most marked differences are to be seen in its more slender habitus, longer tail, differently proportioned head-shields (notably the interparietal), feebly keeled scales, the low number of scales across the body, and fewer femoral pores.

(34) LATASTIA LONGICAUDATA REVOILI (Vaill.).

2 ♂♂, ♀. Near mouth of Kaliokwell River, Lake Rudolf.
♂. Lake Baringo?

(35) MABUYA BREVICOLLIS (Wiegmann).

♂ ♀. Near mouth of Kaliokwell River, Lake Rudolf.

(36) LYGOSOMA SUNDEVALLII (Smith).

2 hgr. Near mouth of Kaliokwell River, Lake Rudolf.
Both specimens have 26 scale-rows.

(37) CHAMAELEON BITAENIATUS SCHUBOTZI Sternfeld.

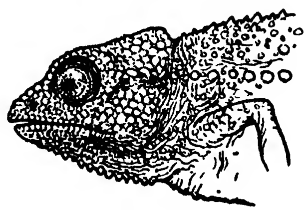
♂. 14,000 ft., Mt. Kenya (*L. C. Beadle*).

This is the first known specimen of this race for which we have a definite altitude and locality. The only previously known specimens were a juvenile from 'Mt. Kenya' and a male and female from an unknown source, but believed by their describer to have been collected on Mount Kilimanjaro. Whether or not the race actually does occur on this latter mountain must be considered doubtful, but there is no doubt that it is to be found at high altitudes on Mt. Kenya.

This fact raises a very interesting question with regard to the relationships and distribution of the various races. Sternfeld (1912) in his papers on the species has discussed some nine races, but for a clearer understanding we may reduce these nine to four principal groups, roughly characterized and distributed as follows:—

I. The *Ch. bitaeniatus bitaeniatus* group (text-fig. 7), including *bitaeniatus*, *ellioti*, *graueri*, and *tornieri*.

TEXT-FIG. 7.



Chamaeleon bitaeniatus bitaeniatus Fischer.

These are forms with a relatively low casque, low gular crest, and no rostral process, the scaling may be more or less heterogeneous, one or two rows of enlarged flat scales are usually present on the flanks and there is some variation in the length, depth, and breadth of the head. They are found over a large area from Abyssinia to Tanganyika and from the Ituri region to western Kenya Colony; they ascend the slopes of Ruwenzori to about 10,000 ft., but do not appear to extend so high in the mountains of Kenya Colony.

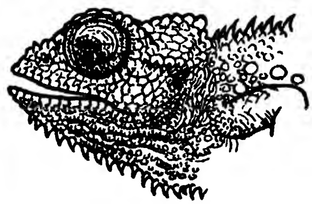
II. *Ch. bitaeniatus rudis* (text-fig. 8) has a low casque, low gular crest, no rostral process, homogeneous scaling except for two slightly enlarged scale-rows on each flank and a short, broad, deep head; it intergrades with group I through *graueri*. It is found only on Mt. Ruwenzori between 10,000 and 12,000 ft.

III. *Ch. bitaeniatus höhneli* group (text-fig. 9); including *leikipiensis*, *höhneli*, and *bergeri*. This group is characterized by a very high casque, long gular crest, and a rostral process; the scaling is heterogeneous and two well-marked rows of enlarged flat scales are usually present on each flank, the upper the better developed. These forms are found throughout the highlands of Kenya Colony from about 6,500 to 11,000 ft., and intergrade with group I through *bitaeniatus*.

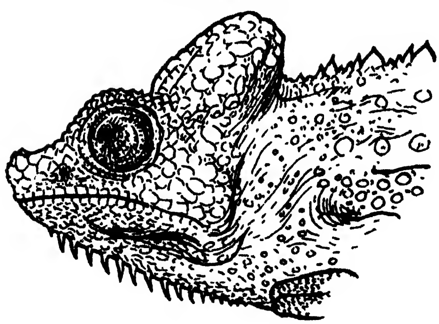
IV. *Ch. bitaeniatus schubotzi* (text-fig. 10) has a low casque, low gular crest, no rostral process, heterogeneous scaling, with two well-developed rows of enlarged scales on each flank, the lower the larger; the head is short, broad, and deep. Mt. Kenya above 11,000 ft.; ? Kilimanjaro.

It is thus seen that in the west the main stock (group I) gives rise at higher altitudes to group II, with complete intergradation between the two. In the east with increasing altitude differentiation has proceeded in quite a different direction, culminating in group III. But group IV, at a still higher altitude in the east, has the scalation of group III combined with the head-characters

Text-fig. 8.



Text-fig. 9.



Text-fig. 10.

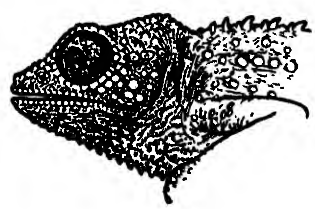


Fig. 8.—*Chamaeleon bitaeniatus rudis* Boulenger.
Fig. 9.—*Chamaeleon bitaeniatus höhneli* Steindachner.
Fig. 10.—*Chamaeleon bitaeniatus schubotzi* Sternfeld.

of group II, and no definite intergradation with any of the other forms can be traced. It is true that Sternfeld records an intermediate with *graueri* from the Kilimanjaro region, but as the occurrence of *schubotzi* on this mountain is doubtful, the status of the 'intermediate' is decidedly questionable.

At first sight it would seem that *rudis* and *schubotzi* are the results of convergent evolution in response to similar environmental conditions, for both occur at very high altitudes. But if this were the case it would not be unreasonable to expect to find analogous forms at intermediate heights on the two mountains which they inhabit. This expectation is not fulfilled, for between about 6,500 and 11,000 feet on Kenya only the high-casqued rostral-horned *höhneli*

is known, whereas on Ruwenzori *graueri* occupies the same zone. In fact, *schubotzi*, although apparently most closely allied to the forms of group I (probably *bitaeniatus*), is entirely separated from it geographically by the *höhneli* group, whereas *rudis* is in direct geographical contact with its nearest relatives. This peculiar situation of *schubotzi* only seems susceptible of explanation in one of two ways:—Either (*a*) it has arisen as an atavistic mutation of *höhneli* or (*b*) *höhneli* is the product of a secondary evolutionary outburst of the stem-form, which has cut off *schubotzi* from its nearest allies and has possibly supplanted a previously existing intermediate.

Which of these explanations is the more probable cannot be gauged except by previously conceived ideas of the methods of evolution. But should it be found that there is on Kilimanjaro a third form analogous with *rudis* and *schubotzi*, and that this is linked with the stem-form by Sternfeld's 'intermediates' mentioned above, a greater degree of probability will be given to the second hypothesis.

(38) TRIONYX TRIUNGUIS (Forsk.).

Juv. Mouth of Kaliokwell River, Lake Rudolf.

(39) CROCODILUS NILOTICUS Laur.

Juv. Mouth of Kaliokwell River, Lake Rudolf.

REFERENCES.

BOULENGER, G. A. 1896. Second Report on the Reptiles and Batrachians collected by Dr. A. Donaldson Smith during his Expedition to Lake Rudolf. Proc. Zool. Soc. London, 1896, p. 216.

HOGBEN & SLOME. 1931. The Pigmentary Effector System.—VI. The Dual Character of Endocrine Co-ordination in Amphibian Colour Change. Proc. Roy. Soc. London, B, cviii, B. 755, pp. 10–53.

LONNBERG, E. 1925. Reptiles, Batrachians, and Fishes collected by the Swedish Zoological Expedition to British East Africa, 1911. Reptiles and Fishes. Svenska Vet.-Akad. Handl. xlvii, 6, pp. 3–24.

LOVERIDGE, A. 1925. Notes on East African Batrachians collected 1920–3 with the Descriptions of four new Species. Proc. Zool. Soc. London, 1925, pp. 763–91.

——. 1932. New races of a Skink (*Siaphos*) and a Frog (*Xenopus*) from the Uganda Protectorate. Proc. Biol. Soc. Washington, xlv, pp. 113–16.

PARKER, H. W. 1932. Two Collections of Reptiles and Amphibians from British Somaliland. Proc. Zool. Soc. London, 1932, xxii, pp. 335–67.

STERNFELD, R. 1912. Der Formenkreis des *Chamaeleon bitaeniatus*. SitzBer. Ges. Naturf. Fr. Berlin, 1912, vii, p. 379.

——. 1912. Wiss. Ergeb. Deutsch. Z. Afr. Exp. iv, Zool. ii, 9, pp. 197–279.

WEST, G. S. 1900. On the Sensory Pit of the Crotalinae. Quart. Journ. Micr. Sci. xliii, pp. 49–59, pl. iv.

WORTHINGTON, E. B. 1932. The Lakes of Kenya and Uganda, investigated by the Cambridge Expedition, 1930–1. Geogr. Journ. lxxix, pp. 275–97.

Scientific results of the Cambridge Expedition to the East African Lakes, 1930–1.—6. Rotifères et Gastrotriches. Par P. de Beauchamp, professeur à la Faculté des Sciences de Strasbourg.

(Avec 4 figures dans le texte)

La collection dont Mr. Worthington a bien voulu me confier l'étude complète heureusement celle de l'Expédition Percy Sladen dont je venais de publier la liste (1932) : en plus de deux lacs déjà explorés par celle-ci, un grand nombre d'autres ont été étudiés dans des conditions variées, et des pêches pratiquées au milieu de la végétation, les numéros 31, 39, 617 * ont permis de recueillir bon nombre d'espèces non pélagiques, d'ailleurs assez banales ; il est singulier en particulier de n'avoir trouvé comme *Lecane* et *Monostyla* que deux espèces communes. J'attendrai néanmoins une autre occasion pour donner un coup d'œil d'ensemble sur la faune rotatorienne de l'Afrique tropicale. Vu le grand nombre des stations, j'énumérerai ici les espèces dans l'ordre systématique en donnant pour chacune les numéros de celles où elle se rencontre † et éventuellement les remarques nécessaires. Les indications d'abondance *a* et *r* seront données seulement dans le cas d'exemplaires extrêmement nombreux ou tout à fait isolés. Comme précédemment j'emploie pour les genres qui n'ont pas encore fait l'objet d'une révision les noms les plus classiques sauf à indiquer les autres, plus ou moins corrects et plus ou moins connus, entre crochets [ ]. Je renvoie au ' Synopsis ' de Harring (1913) pour les compléments de bibliographie et à l'article récent de Bryce (1931) pour l'énumération des travaux concernant l'Afrique.

Bien que simplement fixé au formol, le matériel était en parfait état et permettait en général l'étude des détails les plus délicats. La rétraction, à laquelle d'ailleurs échappent toujours partiellement quelques exemplaires quand ils sont nombreux, n'a pas empêché la détermination des Notommatidés, qui peuvent aujourd'hui grâce aux figures d'Harring et Myers être le plus souvent identifiés par le mastax. Pour les Rhizotes seuls elle a empêché l'attribution de noms précis ; les Bdelloïdes sont, sauf exceptions, inutilisables avec quelque technique que ce soit.

* The numbers throughout refer to the station list (Worthington, 1932).—E. B. W.

† Ceci a l'inconvénient de ne pas mettre en évidence le groupement naturel des espèces, qui ne pourra ressortir que des listes complètes de planeton. Indiquons seulement que le caractère de ceux-ci en ce qui concerne les Rotifères est celui d'associations d'eau douce, sauf pour le Lac Rodolphe et ses dépendances et un petit cratère près du Naivasha, qui ont fourni des documents importants sur l'involution de *Brachionus pala* dans les eaux salées et alcalines.

ROTIFÈRES.

PLOÏMES.

NOTOMMATA COPEUS Ehrbg.

39.

NOTOMMATA CERBERUS Gosse.

39 *r*.

RESTICULA MELANDOCUS Gosse.

617 *r*.

POLYARTHRA PLATYPTERA Ehrbg. [TRIGLA Ehrbg.].

38, 527 *a*, 528.

ASPLANCHNA BRIGHTWELLI Gosse [AMPHORA Huds., SIEBOLDI Leyd.].

28, 31, 603, 623.

TRICHOCERCA [RATTULUS] STYLATA Gosse.

18 *r*, 121, 527, 603, 814, 824.

DINOCHARIS [TRICHOTRIA] TETRACTIS Ehrbg.

39 *r*, 43, 617.

POLYCHAETUS (MACROCHAETUS) COLLINSI Gosse.

31 *r*, 617 *r*.—Les exemplaires de la première station appartiennent à une variété déjà connue (Manfredi, 1927; toutefois les épines des angles latéro-supérieurs sont réduites plutôt que supprimées) sans ergots à la base du pied, les autres sont typiques.

EUDACTYLOTA EUDACTYLOTUM Gosse.

617 *r*.—Ce genre créé par Paola Manfredi en 1927 a la priorité sur *Beauchampella* que Remane a eu l'amabilité de me dédier en 1929.

EUCHLANIS (DIPLEUCHLANIS) PROPATULA Gosse.

617 *r*.

LEPADELLA PATELLA Müller.

31.

MYTILINA VENTRALIS Ehrbg.

39, 617.

MYTILINA VENTRALIS var. BREVISPINA Ehrbg.

43.

LECANE LUNA Müller.

31, 39, 43, 617, 824.

MONOSTYLA BULLA Gosse.

14 *r*, 28, 31, 38, 39, 43, 527, 617, 824, 833.

NOTOPS [EPIPHANES] MOLLIS Hempel.

527, 528, 552 *r*, 603, 814, 824, 833.

De cette espèce créé par Hempel (1886, Illinois) sous le nom de *Brachionus mollis* et redécrite encore plus sommairement par Barrois et Daday (1894, Syrie) sous celui de *Notops macrourus*, nous n'avons qu'une étude un peu détaillée, celle de ce dernier auteur en 1903 (Asie Mineure ; elle a été citée aussi d'Afrique par le même, 1907, de Ceylan par Apstein, Russie par Néizvestnova-Jadina, 1924, et Fadéev, 1925...). Pour préciser la discussion de ses affinités, j'utiliserai en outre du matériel de Dr. Worthington, dont aucun exemplaire n'est entièrement étalé, quelques autres pêchés et préparés par moi en 1907 aux environs de Bourg (Ain), seule localité de France où je connaisse cette rare espèce, qui n'a guère été étudiée à l'état vivant.*

Son attribution générique est en effet discutable ; Jennings (1900), après avoir comparé les matériaux de Hempel à son *Notops pelagicus* déclare que le premier est bien un *Brachionus* comme le second un *Notops* ; je serais plutôt d'un avis opposé pour les raisons qui seront données plus loin... D'autre part Harring ayant reconnu que le g. *Hydatina* porte un nom préoccupé le réunit à *Notops* sous le nom d'*Epiphanes* créé par Ehrenberg pour l'espèce *clavulata* et négligé ensuite. Il est certain que cette espèce † et les quatre autres (*senta*, *brachionus*, *pelagica*, *mollis*) qui formeraient le genre en question ont entre elles des similitudes considérables, mais leur forme générale indique des évolutions dans des sens très différents : elles nécessiteront sans doute une subdivision dont la base ne peut-être encore précisée : l'ébauche de lorica existant chez *brachionus* et *pelagica* est très éloignée de celle, plus accentuée à première vue, que nous allons trouver dans *mollis*. C'est pour ne rien préjuger que j'emploie provisoirement pour elle le nom de *Notops*, car elle ne peut en tous cas rester dans le g. *Brachionus*.

L'animal, vu de profil bien étalé, a pourtant tout à fait l'aspect d'une espèce de ce genre, et en particulier du *Br. pala* dont un assez fort grossissement est nécessaire pour le distinguer : corps renflé surtout dans la région lombaire, à cuticule transparente et dépressible, à cavité spacieuse, prolongé par un pied très long dans l'extension complète (qui est rare, texte-fig. 1, A) et finement ridé transversalement même alors,‡ renfermant des glandes très

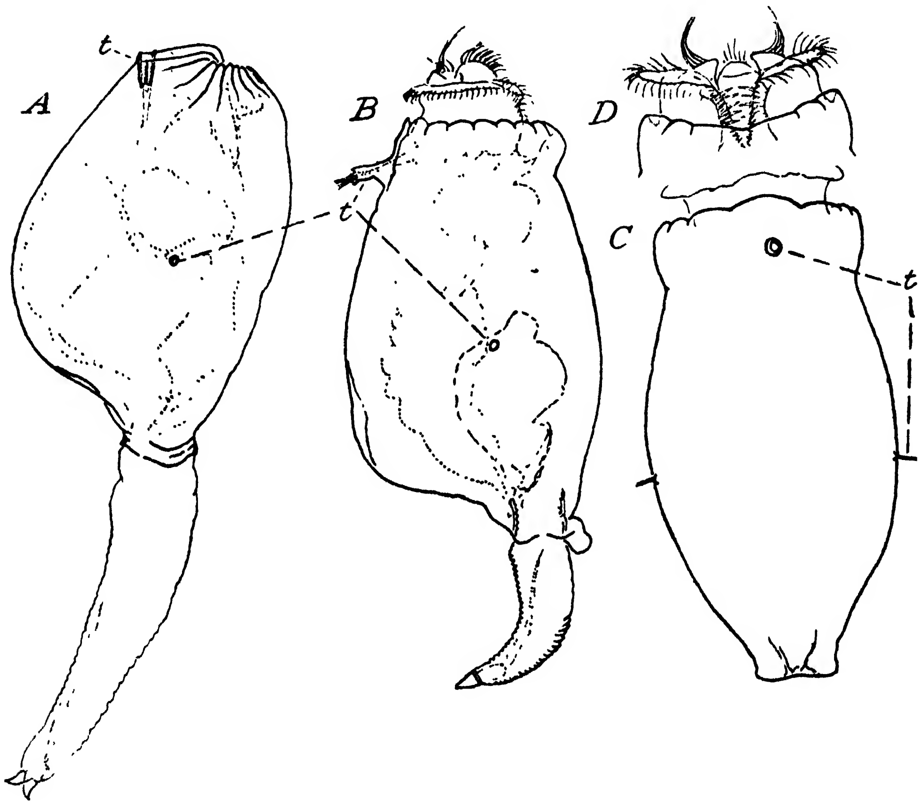
* C'est d'après eux qu'a déjà été fait un schéma donné à la p. 20 de mon travail de 1909 et où la position aberrante du tentacule nucal est mal indiquée ; il est intercalé, dans le simple but de donner une idée de l'évolution de la lorica, entre *Notops brachionus* et *Brachionus pala*, ce qui est systématiquement inexact, comme nous allons le voir.

† La réduction du pied et le gonflement du corps qui lui donnent un convergence d'aspect si remarquable avec un *Asplanchnopus* se sont produits parallèlement chez une espèce du g. voisin *Rhinops* [*Rhinoglena*], *R. fertoënsis* Varga, 1926.

‡ Il est en général à moitié rétracté comme l'a figuré Hempel dont le dessin (que je suppose celui reproduit par Jennings dans ' Synopsis of North-American Invertebrates ' ; je n'ai pu voir la diagnose originale) correspond à notre texte-fig. 1, B, tandis que Barrois et Daday l'ont indiqué étalé, et c'est ce qui fait que les auteurs ont pris l'un ou l'autre nom. Apstein en 1910 reconnaît sur l'indication de Rousselet que son *N. macrurus* (telle est l'orthographe qu'il emploie) doit s'appeler *mollis*.

minces terminées par un réservoir hémisphérique au dessus des deux petits orteils pointus et un peu courbés vers l'extérieur. Sur une vue frontale (texte-fig. 1, *c*), déjà donnée par Daday, l'aspect est tout autre: le tronc a une forme d'amphore, beaucoup plus étroite que chez les Brachions (dont

TEXTE-FIG. 1.



Notops mollis Hempel.

A. De profil, couronne rétractée, pied étalé, du Lac Edouard. B. De profil, couronne étalée, pied à moitié rétracté, de Bourg (Ain) ainsi que les suivants. C. Vue dorsale, pied complètement rétracté. D Couronne, vue ventrale. Tous × 265.

t., tentacules nucal et lombaire.

N. brachionus et *pelagicus* ont au contraire le galbe) et rappelant plutôt en plus rigide celui d'*Hydatina senta*. D'autre part la lorica, aussi épaisse en apparence que celle de *Br. pala*, se termine pourtant en haut par un rebord sans dents, mais avec des ondulations régulières qui correspondent aux plis de

l'orifice fermé en bourse lors de la rétraction, chose impossible chez les Brachions où tout au plus il se rétrécit légèrement. Il y a une vingtaine de ces bourrelets arrondis, qui manquent ventralement, car le bord mental est droit ou un peu déprimé. Sur la ligne médiane dorsale au contraire se trouve un bourrelet impair un peu plus marqué et surplombant à l'état de contraction. Tous les Brachions sauf *B. tridens* Hood (si cette curieuse espèce n'est pas fondée sur une anomalie ou une erreur d'observation) ont là par contre une échancrure par où sort le tentacule nucal, et Jennings dit qu'il en est de même dans notre espèce, ce qui est inexact : chez elle *le tentacule est inséré sur la lorica même,* bien au-dessous du bord supérieur.*

L'erreur sur ce point fondamental tient d'abord à ce que sur l'aspect de profil le tentacule apparaît intercalé entre deux plis longitudinaux qui semblent les bords d'une telle échancrure, ensuite à ce qu'il est à première vue invisible quand la couronne est rétractée, ce qui fait croire qu'il l'est avec elle ; en réalité on le retrouve alors (texte-fig. 1, A) sous forme d'une petite protubérance à la base du pli impair, et on constate alors qu'il est complètement invaginé en doigt de gant par la traction d'un muscle (ou tout bonnement de son nerf, la paroi étant refoulée en dehors par la pression interne). En tous cas il y a là un caractère qui écarte *N. mollis* aussi bien des Brachions que des *N. brachionus* et *pelagicus* qui ont la même disposition que ceux-ci malgré leur lorica à peine ébauchée ; le dernier a même le bord nucal découpé en 4 courtes dents, et c'est pour cela que je l'ai dit plus voisin des Brachions. Ce bord nucal de la lorica n'est pas homologue dans les deux cas. Ce n'est que dans une famille fort éloignée, celle des Trichocercidés [Rattulidés] que l'on voit la lorica continuée vers le haut par une gaine collaire capable aussi de se plisser et donnant insertion au tentacule. On peut aussi rappeler le cas des *Dinocharis* [*Trichotria*].

Les tentacules lombaires sont situés vers le milieu de la longueur de la lorica, un peu plus haut que dans les formes voisines. A la base du pied celle-ci ne forme qu'un repli dont le contour peut varier. Il existe latéralement plusieurs paires de muscles circulaires, ou plutôt transversaux car ils sont courts, mais ceux-ci se trouvent aussi chez *Br. pala* dont la lorica est également souple ; par contre le sphincter continu qui ferme son orifice n'existe bien entendu pas chez celui-ci. Le reste de l'organisation n'a rien de remarquable, pour autant qu'il peut être étudié à l'état fixé. L'appareil rotateur très sommairement indiqué par Daday est tout à fait du type indiqué par Jennings pour *N. pelagicus* et *clavulatus* et qui diffère à peine de celui de l'Hydatine. La bande ciliée périphérique ne se découpe pas en lobes saillants comme chez les Brachions, caractère qui paraît d'abord chez ceux-ci en rapport avec les épines du bord de la lorica entre lesquelles ils s'intercalent, et qui pourtant n'existe pas chez les *Noteus* [*Platyias*] où celles-ci sont très développées... Le mastax malléé à 7 dents serait difficile à distinguer de celui des formes voisines.

* Daday, chose singulière, ne figure pas la lorica, ni par suite son rapport avec le tentacule qu'il indique et dont il paraît donner la présence comme un caractère différentiel vis-à-vis de *N. brachionus* !

Brachionus angularis Gosse.

28 *a*, 31 *a*, 38 *a*, 43, 216 *r*, 527, 528, 530, 603, 623 *a*, 814 *a*, 824, 833.

Brachionus angularis var. caudata Barrois et Daday.

31 (2), 38, 43, 530, 603, 623 *a*, 824.

Forme déjà souvent signalée en Afrique. C'est à elle et non à *Br. pala* [*calyciflorus*] comme le dit par mégarde Harring, 1913, que se rapporte *Br. tetracanthus* Collin de la même région. La longueur des épines bordant le pied est très variable, les plus courtes se trouvent dans le lac Kachira, 824.

Brachionus budapestinensis Daday.

833 *r*.

Brachionus pala Ehrbg. [calyciflorus Pall.].

14, 28, 38, 250 *r*, 528, 530, 814, 824, 833.

Brachionus pala var. amphiceros Ehrbg.

527, 528, 603, 623.

Brachionus pala var. spinosa Wierzejski.

623.

Brachionus pala var. quartaria, nov.

31 *r*, 117 *r*, 211 B, 248 *a*, 250, 257, 258.

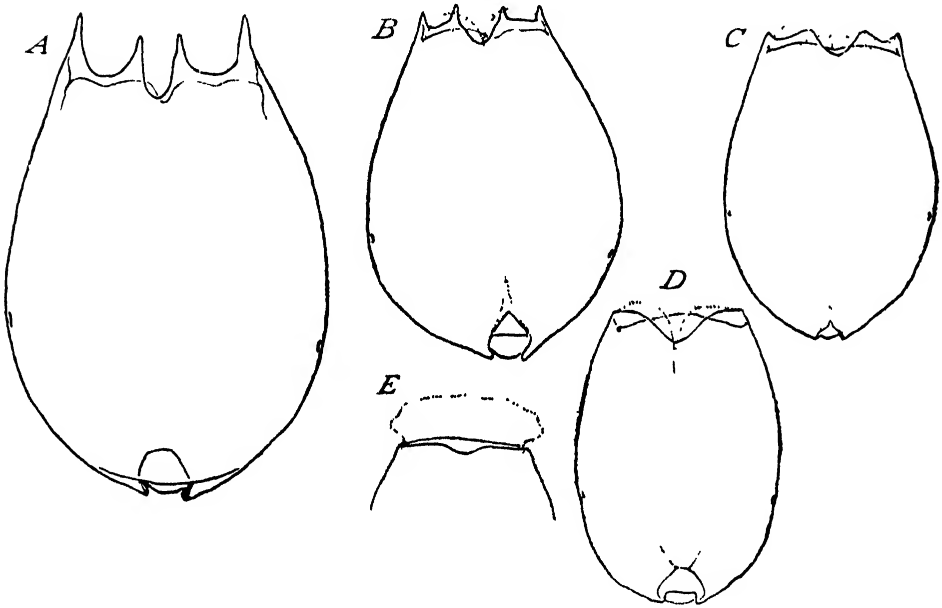
Brachionus pala var. inermis Schmarda.

33.—Ces deux dernières formes sont d'un intérêt tout spécial et me permettent de compléter ce que j'ai dit en 1932 de la réduction du *Br. pala* dans les eaux salées, laquelle peut arriver à un degré dépassant de beaucoup celui du *Br. pala dimidiatus* Bryce que je connaissais seul alors. A part deux individus peut-être moins réduits, dans les lacs Naivasha et Baringo, *Br. pala quartarius* a été trouvé exclusivement dans le lac Rodolphe et les marais alcalins qui en dépendent, associé presqu'uniquement à *Br. plicatilis* ce qui suffirait à démontrer le caractère salin de ces eaux (bien que ce dernier soit un peu plus répandu dans notre matériel). La réduction de la taille et des épines est très marquée par rapport aux *dimidiatus* (texte-fig. 2, A et B) (120 μ) et la lorica est très mince de sorte que les trois bourrelets arrondis (deux dorsaux, un ventral) formés par le tégument collaire invaginé et indiqués en pointillé sur les figures sont à peine moins accentués que sa limite supérieure. Dans un exemplaire même (texte-fig. 2, C) la taille était encore plus faible et les dents réduites à des ondulations du rebord.

C'est la connaissance de cette forme qui m'a permis d'interpréter le singulier petit Rotifère trouvé en quelques exemplaires dans le lac-cratère 33 qui n'en renfermait aucun autre, au milieu d'un plancton dense de Cyanophycées (*Spirulina* ?) qui paraît caractéristique de ces eaux minéralisées (il sera intéressant de savoir si celle-ci l'était plus que les précédentes). Je l'avais

d'abord rapporté au genre *Pompholyx*, mais quelques-uns ont un pied étalé qui garde les caractères de celui de *Br. pala*, et il n'est pas douteux qu'il représente le terme ultime et imprévu de la réduction de cette espèce. Régulièrement ovoïde, long de 95 μ seulement, il a un bord supérieur tout à fait dépourvu d'épines et très souple, de sorte qu'il se distingue à peine des bourrelets déjà mentionnés et que dans le cas de forte rétraction il se déprime en une large échancrure dorsale, tandis que si la couronne est sortie il est à peine sinueux (E). Le côté ventral reste à peu près droit, le bourrelet adjacent étant impair. Pour

TEXTE-FIG. 2.



Formes réduites de *Brachionus pala* Ehrbg., loricas.

A. *dimidiatus* Bryce, d'Abyssinie. B. *quartarius*, var. nov., du Lac Rodolphe. C. Autre forme du même. D. *inermis* Schmarda, pêche 33. E. *inermis* Schmarda, bords supérieurs, couronne étalée. Tous vue dorsale, × 400.

la comparaison je figure à nouveau au même grossissement que les formes ici décrites le type *dimidiatus* de Bryce (Abyssinie) que j'ai retrouvé presqu'identique dans le lac Elmenteita.

Pour nommer cette forme je fais usage d'un vieux nom de Schmarda (1854) que était considéré comme douteux, vu la simplicité de sa figure, mais se rapporte à lui aussi bien que la permettent des caractères purement négatifs. Le fait qu'il a été trouvé en Egypte dans les lacs Natron corrobore le rapprochement ; il paraît toutefois avoir une taille au moins double. Personne sans

les intermédiaires qui viennent d'être décrits n'aurait eu l'idée de le rapporter au cycle de variation de *Br. pala.**

BRACHIONUS URCEOLARIS Ehrbg. [CAPSULIFLORUS Pall.] var RUBENS Ehrbg. [URCEUS L. ?].

31.

BRACHIONUS BAKERI Ehrbg. [TRIDENTATUS Hermann].

31, 43, 814 *r*.

BRACHIONUS BAKERI var. CLUNIORBICULARIS Skorikov.

31, 43.

BRACHIONUS FALCATUS Zacharias.

121 *r*, 814, 824.

BRACHIONUS PLICATILIS Müller [MÜLLERI Ehrbg.].

106 *r*, 211 B *r*, 234, 248 *a*, 250 *a*, 258, 271 *a*, 527 *r*, 814 *r*.

BRACHIONUS MILITARIS Ehrbg. [PATULUS Müller].

12 †, 106 *r*, 814.

NOTEUS [PLATYIAS] QUADRICORNIS Ehrbg.

ANURAEA ACULEATA Ehrbg. [KERATELLA QUADRATA Müller] var. VALGA Ehrbg.

12, 14 *a*, 18 *a*, 28 *a*, 31 *a*, 38 *a*, 43, 106 *a*, 117 *a*, 121 *a*, 527, 528, 530 *r*, 552 *r*, 571 *r*, 603 *a*, 623, 814, 824, 833.—L'espèce la plus fréquente et la plus abondante des planctons d'Afrique tropicale et, comme tous les auteurs l'ont noté, presque toujours sous cette forme à épines inférieures asymétriques, d'ailleurs plus ou moins longues.

ANURAEA ACULEATA var. STIPITATA Ehrbg.

31.

ANURAEOPSIS FISSA Gosse [HYPELASMA Gosse].

814, 833 *r*.

ANURAEOPSIS NAVICULA Rousselet var. COELATA, nov.

814.—L'histoire de cette espèce se réduit à ma connaissance à sa description par Rousselet en 1911 dans un plancton du lac Gregory, Ceylan, communiqué par Apstein, qui en avait donné un croquis en 1910. L'animal assez abondant dans le lac Nakavali, où se trouvait aussi la précédente espèce banale, paraît à première vue assez différent de ses figures comme le montrera la comparaison

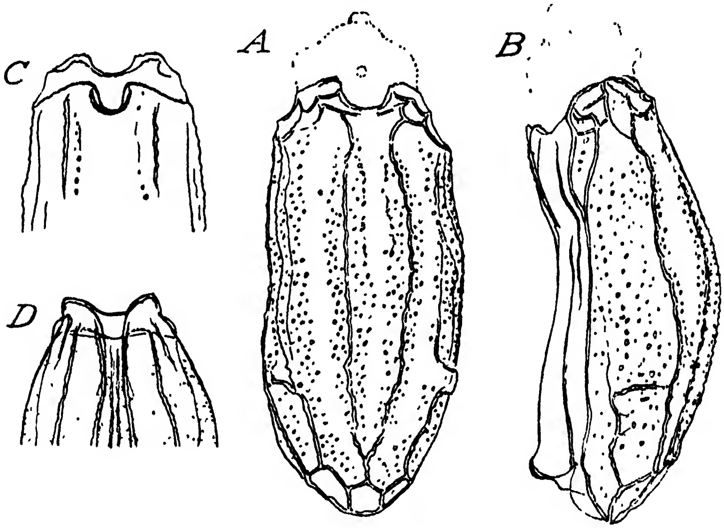
* Toutes ces formes restent bien distinctes du *Br. angularis*, qui a aussi des types très réduits, par la lorica globuleuse non aplatie ni divisée en plaques dorsale et ventrale, qui caractérise par rapport aux autres Brachions la série du *Br. pala* et celle du *Br. plicatilis*. Les formes réduites de celui-ci (Murray, 1913) gardent une grande taille et des ondulations au bord mental.

† From stomach of Fish, *Tilapia nigra*.—E. B. W.

avec les nôtres (texte-fig. 3) ; il semble que ces divergences portent sur des détails de forme et d'ornementation qu'on a l'habitude de voir varier amplement dans le g. voisin *Anuraea* et qui n'ont peut-être pas été indiqués avec une précision absolue dans les premiers dessins ; aussi je ne veux en faire qu'une variété.

La taille est exactement la même, 92 μ, et minuscule pour un Rotifère comme le dit R. La forme de la lorica paraît moins effilée aux extrémités ; pour la supérieure au moins, cela semble tenir à ce que mes individus avaient en général la couronne étalée, et qu'il y a rétrécissement quand elle est rentrée (D). L'aspect est alors bilobé, les deux bords finement denticulés, le dorsal débordant

TEXTE-FIG. 3.



Anuraeopsis navicula Rousselet var *coelata*, nov., du lac Nakavali.
A. Vue dorsale. B. Vue de profil. C. Bords supérieurs, vue ventrale.
D. Bords supérieurs, vue dorsale, couronne rétractée. Tous × 570.

le ventral, ayant chacun une encoche, plus large et plus basse au premier ; R. dit que le ventral est droit, mais sa figure, comme celle d'Apstein, semble indiquer plutôt une ligne transversale sous une échancrure. Sur la face dorsale, régulièrement bombée, se trouvent quatre crêtes longitudinales qui en haut et en bas se ramifient pour limiter des aréoles polygonales dont les figures montrent suffisamment la disposition. Elles portent aussi des ponctuations saillantes, très irrégulières comme taille, contour et répartition, qui ne s'étendent pas au fond des trois sillons délimités par elles ; au contraire, elles couvrent complètement les deux sillons situés en dehors, sauf un petit espace, un peu saillant au dessus d'une crête transversale située au quart inférieur, où se trouve certainement le tentacule lombaire bien que je n'aie pu l'apercevoir.

La plaque ventrale ne présente aucune ornementation sauf deux courtes crêtes longitudinales près du bord supérieur, doublées en dedans d'une rangée de ponctuations. R. n'a figuré ni crêtes ni aréoles, mais une ponctuation uniforme sur toute la lorica.

Cette plaque ventrale est un peu plus courte que l'autre et légèrement échancrée au-dessus de l'anus. A sa jonction avec l'autre se trouvent un ou deux plis assez mal définis qui donnent beaucoup moins que chez *A. fissa* l'impression d'un soufflet mince séparant deux plaques rigides. On ne peut rien voir du reste de l'organisation, sauf le contour de la couronne, dont la protubérance ciliée médiane est très saillante, et le mastax malléé très semblable à celui de l'autre espèce. On ne peut en particulier reconnaître la présence du sac rétro-cérébral bien développé de celle-ci.

TRIARTHRA [FILINIA] LONGISETA Ehrbg.

14, 18, 28, 43 *a*, 527 *r*, 528, 603, 833 *a*.

TRIARTHRA LONGISETA var. LIMNETICA Zacharias.

31, 106, 117 *a*, 121 *a*, 824.

TETRAMASTIX OPOLIENSIS Zacharias.

28 *r*, 43 *a*, 117, 121 *a*, 814 *a*, 833.

PEDALIA MIRA Hudson.

117.

PEDALIA INTERMEDIA Wiszniewski.

14 *r*, 28, 31 *r*, 38 *a*, 43, 117, 121 *a*, 527, 528, 623, 814.—Cette espèce, confondue avec la précédente jusqu'il y a trois ans, était beaucoup plus commune qu'elle dans ce matériel. Dans la seule pêche du lac Baringo où elles se rencontrent ensemble, les exemplaires en mauvais état laissaient peu voir les caractères extérieurs et il était nécessaire de préparer les mastax pour les séparer.

PTERODINA [TESTUDINELLA] PATINA Hermann.

814 *r*, 824 *r*.

RHIZOTES.

OECISTES [PTYGURA], LACINULARIA [SINANTHERINA], MEGALOTROCHA.

Ces trois genres, auxquels il faudrait peut-être ajouter *Pseudoecistes* Stenroos et *Voronkowia* Fadéev sont à mon sens fort peu séparés et l'on manque de bons caractères pour attribuer à l'un d'eux une espèce, surtout quand la couronne est rétractée ; la vie coloniale ou libre ne peuvent suffire à cet égard. D'ailleurs la plupart des formes connues sont assez vaguement décrites. Je préfère donc énumérer, sans attribution précise, celles que j'ai pu séparer dans la végétation du Naivasha :—

A. 31.—Une espèce coloniale de grande taille, tégument épais et ridé, deux petits yeux, uncus à trois grosses dents principales espacées.

B. 31, 43.—Une espèce isolée, pied très allongé, 2 gros yeux peut-être inconstants, uncus à 3–4 dents principales de taille décroissante.

C. 39.—Une espèce coloniale fixée de grande taille à gelée abondante, premières dents décroissant régulièrement.

D. 39.—Colonies fixées plus petites et plus rares, deux petits crochets au-dessus de l'appareil rotateur rétracté, premières dents très fines.

E. 39.—*Oecistes longicornis* Davis ? Forme fixée isolée à fourreau assez mince chargé de Diatomées et autres corps bruns en stries radiaires, tentacules pairs longs, à l'inverse des précédents, pas de crochets, pédoncule sécrété assez développé.

LIMNIAS ANNULATUS Bailey [MELICERTA Weisse].

39.

CONOCHILOIDES DOSSUARIUS Hudson.

31, 117 *a*, 814.—Tous les exemplaires paraissent bien appartenir à cette espèce, dont *C. coenobasis* Skorikov, 1914, n'est sans doute pas distinct. La base commune des deux tentacules est de longueur relative très variable suivant la contraction.

FLOSCULARIA [COLLOTHECA] sp.

39.—Un seul exemplaire qui paraît avoir la couronne trilobée.

BDELLOÏDES.

ROTIFER NEPTUNIUS Milne [ROTARIA NEPTUNOIDA Harring].

31, 527.

DISSOTROCHA ACULEATA Ehrbg. var MEDIOACULEATA Janson.

617.—Possède une 14e petite épine sur la ligne médiane devant les autres.

Bdelloïdes indéterminables.

18, 31, 39, 43, 271, 527, 530, 617.

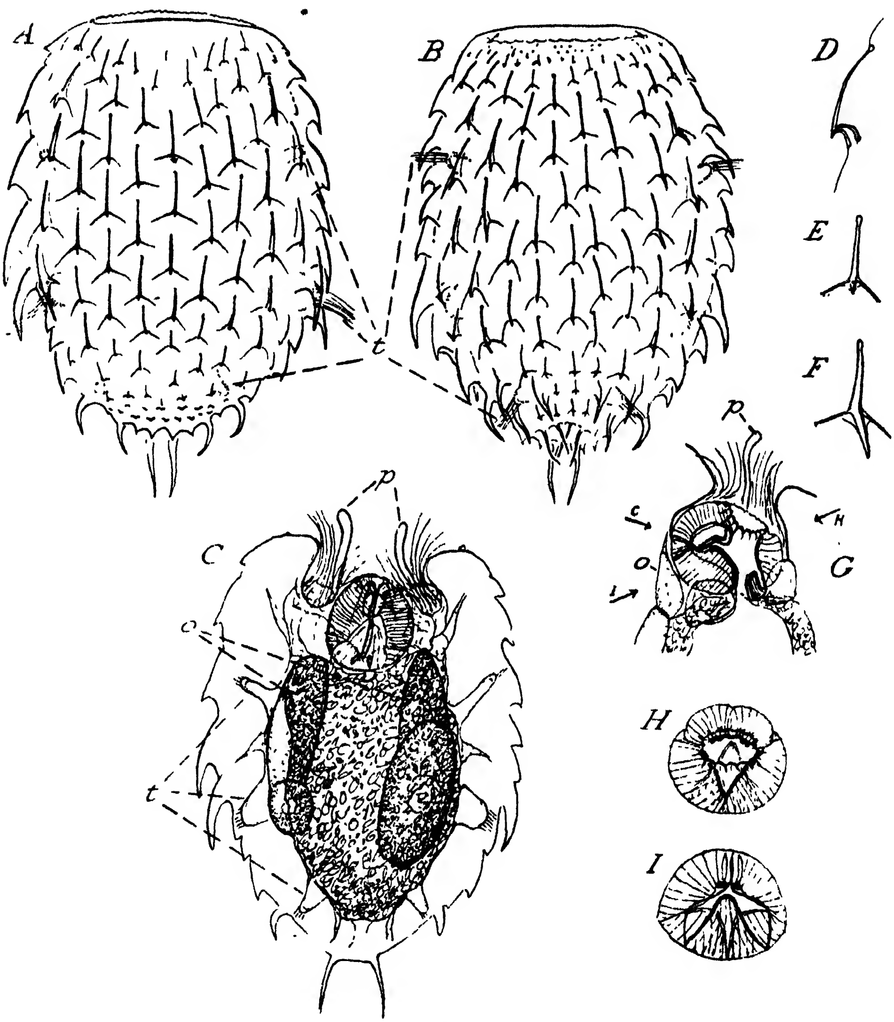
GASTROTRICHES.

KIJANEBALOLA, gen. nov. [*Eretmia* Gosse *pro parte* ?].

KIJANEBALOLA DUBIA, sp. n.

Le singulier animal dont il va s'agir a été trouvé dans le plancton 833 du lac Kijanebalola en deux exemplaires seulement : après la découverte du premier et vu l'intérêt qui s'attachait à élucider ses particularités, Dr. Worthington a bien voulu me confier le reste de cette pêche, une trentaine de centimètres cubes dont l'examen minutieux et pénible vu l'abondance des Copépodes et des Chroococcacées ne m'en a procuré qu'un second, qui a pu être monté en préparation. Ils étaient d'ailleurs en excellent état et m'ont fourni tout ce qui était possible dans ces conditions. Nous verrons que la seule forme connue (plutôt mal) dont il soit possible de le rapprocher a été considérée

TEXTE-FIG. 4.



Kijanebalola dubia, gen. et sp. n.

A. Aspect extérieur, vue ventrale. B. Aspect extérieur, vue dorsale. C. Organes internes, vue ventrale; les trois ×450. D, E, F. Détail des épines, ×675. G. Pharynx vu de profil; les flèches indiquent approximativement la direction des vues portant la même lettre. H et I. Le même vu respectivement par le bout buccal et le bout cardiaque.

o., ovate; *p.*, prolongements tentaculiformes céphaliques; *t.*, touffes ciliaires latérales.

successivement comme un Rotifère et comme un Rhizopode ; je ne puis en faire qu'un Gastrotriche Chaetonotoïde, d'ailleurs passablement aberrant.*

Aux faibles grossissements il apparaît (texte-fig. 4, A et B, où l'animal comprimé est un peu trop large) comme une petite coque longue de 150 μ environ, presque régulièrement ovoïde, épineuse sauf au niveau de son orifice, qui donne bien l'impression d'un test de Rhizopode voisin des Euglyphes ; un examen plus approfondi révèle une structure différente et une masse viscérale entourée d'une cavité spacieuse, raccordée à l'orifice, dont s'échappent des cils, par un repli annulaire de tégument très mince. En effet, l'extrémité céphalique est invaginée, ce qui rappelle plus les Rotifères que les Gastrotriches, lesquels se raccourcissent ou se tordent simplement à la fixation.

L'aspect épineux et réticulé de la coque est dû à des protubérances, soulèvements creux de la cuticule dont on ne peut distinguer l'épiderme, qui sont alignées en quinconce, c'est à dire en une vingtaine de rangées longitudinales (8 ou 9 par rangée y compris les petites des extrémités) avec alternance d'une file à l'autre. Je les appellerai écailles faute d'un meilleur mot, mais elles ne sont pas superposées à la cuticule, ni formées par son épaississement, elles en sont de simples gaufrures. Comme le montrent les fig. D, E, F, ce sont des pyramides triangulaires creuses à arêtes un peu courbes, la plus grande étant longitudinale. Celle-ci présente un double contour et se termine en haut par un petit renflement, en bas par une pointe, à peine saillante habituellement à la jonction des deux autres, mais qui sur certaines écailles s'allonge en une véritable épine crochue. Celles qui présentent ce caractère se trouvent à l'extrémité inférieure et sur les côtés du corps, les plus longues au nombre de trois étant un peu au-dessous du milieu.

Dans le bas de la face ventrale † les écailles diminuent rapidement de taille et se réduisent à de petits accents circonflexes retournés ; le bord terminal présente quatre denticules accompagnant semble-t-il l'anus. Du côté dorsal les écailles ne rapetissent que sur la ligne médiane, les latérales s'allongent en épines formant deux groupes de 5 ou 6. Plus bas se trouvent de véritables soies, une rangée transversale de 4 et 2 terminales plus longues. A la partie supérieure les écailles se réduisent aussi rapidement ; du côté ventral elles s'arrêtent assez brusquement, laissant lisse, du moins chez l'exemplaire le moins contracté, la lèvre de l'orifice, tandis que du côté dorsal elles se résolvent en petites granulations qui denticulent celle-ci.

Enfin sur les côtés du corps existent trois touffes de cils longs et un peu flexueux correspondant comme position aux groupes d'épines allongées qui les

* Pour toutes les allusions à l'anatomie des Gastrotriches je renvoie aux deux ouvrages de Remane, 1926 et 1929.

† Il n'est pas aisé d'identifier le dos et le ventre, le cerveau n'étant pas visible et la position des gonades pouvant varier chez les Gastrotriches. J'ai considéré comme dorsal le côté où les épines des extrémités sont le plus développées, ce qui implique que la bouche est déviée dorsalement par la rétraction et les œufs développés ventraux.

entourent ; la plus développée se trouve comme pour ceux-ci la médiane, placée près du tiers inférieur. Elle est un peu ventrale tandis que les deux autres sont plutôt dorsales. Elles sont insérées sur le tégument sans dépression ni saillie, mais à chacune correspond une papille assez large qui part de la masse viscérale pour s'accoler au tégument à leur niveau par un épaississement de sa paroi creuse...

La structure du tégument, tout à fait étrangère aux Rotifères, suggère au contraire un Gastrotriche : presque toutes les formes d'écailles et d'épines si fréquentes et variées dans ce groupe se ramènent vraisemblablement au schéma ci-dessus avec des proportions différentes du triangle ou trièdre basal et du prolongement qui le termine. Les soies terminales ont une grande analogie avec celles des *Neogossea* que j'ai eu l'occasion d'étudier en 1930 (forme également pélagique) et dessinent une ébauche de furca. Une différence importante est que tous les Gastrotriches ont sur la face ventrale une ciliation continue ou non dont il n'y a ici nulle trace. Il est vrai que chez *Proichthydium* elle se raccourcit en une plaque buccale supérieure qui disparaîtrait si la tête s'invaginait comme dans notre animal... Les trois paires de touffes ciliaires sont-elles un reste de cette ciliation du corps ? Elles ne paraissent pas locomotrices vu le développement des groupes d'épines qui les protègent et il semble tentant de les homologuer aux tentacules des Rotifères (dont les Gastrotriches n'ont nulle trace), bien que ceux-ci ne forment pas plus de deux paires * et aient un aspect en pinceau raide assez différent...

De la tête invaginée s'échappent par l'orifice supérieur des cils assez longs surtout latéralement et deux prolongements digitiformes allongés et un peu renflés à l'extrémité, semblant formés de protoplasme hyalin. Il en existe de semblables, pairs ou impairs, chez divers Rotifères (*Ascomorpha*, *Anapus* [*Chromogaster*], Trichocercidés), mais aussi chez les Gastrotriches *Thaumastoderma* et *Neogossea* encore. L'analogie est marquée avec le dernier de ces genres, car la bouche, déviée vers la face dorsale comme il a été dit, apparaît entourée d'un repli circulaire à bord denticulé, il est vrai non soutenu par des soies développées.

Le pharynx qui lui fait immédiatement suite offre un caractère encore plus particulier et qui renforce l'apparence composite de l'animal. Sa forme ovoïde et courte l'écarte du pharynx des Gastrotriches dans son ensemble, mais il ressemble beaucoup à la moitié proximale du pharynx de *Neogossea* qui forme un véritable bulbe renflé analogue à celui de beaucoup de Nématodes ; j'ai d'ailleurs montré que dans l'embryologie la formation de la moitié distale est tardive. Par contre il renferme des parties dures, différenciations cuticulaires qui manquent aux Gastrotriches, et sous une certaine incidence, en vue exactement ventrale, elles présentent une similitude frappante avec

* Il est vrai qu'on pourrait considérer l'organe sensoriel caudal de certains Notommatidés comme primitivement pair de même que le tentacule nucal qui le reste quelquefois. D'ailleurs Remane (1929–32 et 1932) vient de décrire chez les Rotifères plusieurs autres organes sensoriels pairs ou non, ce qui ôte toute importance à leur nombre.

les trophi de certains mastax virgés (texte-fig. 4, C) : on croit distinguer un fulcrum surmonté de deux ramus, et en haut et en bas d'autres petites pièces dont les premières pourraient être des uncus... Mais dès que l'organe tourne d'un certain angle, l'apparence change et ne montre plus aucune similitude avec un mastax ; le contour régulier, la lumière spacieuse, les parois entièrement musculaires s'opposent d'ailleurs au rapprochement. Enfin la dissolution du premier exemplaire dans l'hypochlorite, qui n'a pu d'ailleurs être suivie en détail, a isolé au lieu du système solide et cohérent que laisse tout mastax en pareil cas des plaquettes cuticulaires irrégulières, elles-mêmes rapidement dissoutes.

Après de nombreux examens sous toutes les faces, surtout du second exemplaire où l'axe de l'organe devenu presque dorso-ventral permet des vues en bout, je suis arrivé à une interprétation aussi satisfaisante que le permettait la pauvreté du matériel et que font comprendre les figures légèrement schématisées G, H, et I. Ce pharynx se ramène comme sans doute tous les pharynx de Vers * (en particulier le mastax comme je l'ai montré en 1909, mais celui-ci extrêmement différencié), à un stomodeum musculeux formé de fibres surtout radiaires, et dont la lumière triradiée est revêtue d'une cuticule : c'est le cas simple des Gastrotriches. Ici la cuticule s'épaissit par place comme dans beaucoup d'autres cas, et de plus la lumière prend une forme compliquée du fait que l'organe est court et qu'elle passe d'une section en Y à la bouche (donc dorsalement avec l'orientation indiquée) à une section en λ plus bas. Les plaquettes cuticulaires, en noir sur les schémas, l'accompagnent bien entendu. Il en résulte les apparences représentées ; les soi-disant ramus tapissent les culs de sac latéraux mais se réunissent vers la bouche, la baguette fulcrale n'est que l'angle aigu du repli médian, ce qui explique qu'elle s'efface quand on fait tourner l'organe.

Autour du pharynx et des cils, les parois retournées de la tête forment un ensemble cellulaire où l'on ne peut voir nettement le cerveau, et peut-être les glandes digestives, qui s'y trouvent. Le reste de la masse viscérale plonge librement dans une cavité beaucoup plus spacieuse qu'il n'est habituel chez les Gastrotriches et que limite en dehors la cuticule déjà décrite. On n'y distingue aucun organe, muscles ou néphridies, seulement trois paires de papilles aboutissant aux touffes ciliaires déjà décrites (et qui n'ont nullement l'apparence de nerfs) et autant de tractus plus effilés qui sont peut-être musculaires. Les deux derniers, de part et d'autre d'un rectum fort peu visible, pourraient à la rigueur être des oviductes indépendants de lui : ceux-ci existent chez *Neogossea* où j'ai suivi la ponte. On peut se demander si tout l'espace périviscéral n'est pas en réalité un décollement produit à la fixation (il préexistait à l'éclaircissement par la glycérine) entre la cuticule et l'épiderme qui serait avec les muscles accolé à la masse centrale...

* Et ceux de quelques autres types. Sous certaines incidences l'analogie est frappante aussi avec le pharynx des Tardigrades qui renferme de même des parties épaissies.

On ne distingue pourtant dans celle-ci que deux constituants, dont le principal est un tube digestif tout d'une venue, à lumière peu nette, la paroi étant criblée d'inclusions réfringentes et inégales, les uns irrégulièrement ovoïdes, les autres bacillaires. La similitude avec celui de *Neogossea* est là encore frappante. On aperçoit en plus deux ovaires, masses finement granuleuses aplaties à sa surface. Dans le second exemplaire ils sont peu développés, franchement latéraux et très haut, au contact du pharynx. Dans le premier (C) on distinguait à la suite deux œufs ventraux inégalement développés, le plus grand à gauche, avec gros noyaux (chez *Neogossea* et beaucoup de Gastrotriches les œufs prêts à être pondus sont dorsaux).

Il nous reste à établir si quelque chose d'analogue a jamais été décrit. En 1886, dans son grand traité en collaboration avec Hudson, vol. 2, Gosse crée le genre *Eretmia* avec quatre espèces (deux dans l'Addendum, p. 134) pour des Rotifère voisins des *Anuraea* ayant des épines sur la lorica mais non au bord supérieur. La seconde citée, *E. cubeutes*, est une coque ovoïde ressemblant à celle d'un Rhizopode, partagée par des sillons en losanges réguliers et portant une épine ventrale, une dorsale (? Ne seraient-elles pas plutôt latérales ?) et quatre inférieures. Il est certain que notre animal observé avec un instrument médiocre donnerait un aspect très analogue en supposant les grandes épines moins nombreuses et plus longues, ce qui peut être une différence spécifique. Gosse n'a pas vu l'animal vivant, mais dit que Hood l'a observé nageant, avec un appareil rotateur triparti, apparence que peut donner la tête d'un Gastrotriche ; il figure aussi un œil rouge avec un cristallin (il n'est pas sûr que j'aurais pu le retrouver s'il existait dans mes exemplaires).

En 1906, J. Murray dans les Lochs Ness et Hunna a trouvé de nombreux exemplaires morts qu'il rapporte avec doute à cette espèce. D'après sa note, Rousselet estimait qu'il s'agissait de coques de Rhizopodes (M. fait pourtant remarquer qu'elles diffèrent fort des *Euglypha*, les seuls dont on pourrait les rapprocher) habitées par un Rotifère dont on aperçoit le mastax (cette apparence pourrait être donnée par notre animal ; par malheur aucun dessin n'a été publié). L'observation de Hood rend cette interprétation assez peu vraisemblable ; il est en tous cas illégitime de la généraliser à toutes les *Eretmia* comme le fait Harring dans son 'Synopsis.' D'après les renseignements obligeamment fournis par Mr. D. Bryce et Mr. C. Tierney, Secretary of the Royal Microscopical Society, il n'existe malheureusement aucune *Eretmia* dans les préparations de Rousselet et de Murray qui ont été conservées.

Si je crée ici un nouveau nom de genre, c'est parce qu'*E. cubeutes*, très probablement congénérique à la présente espèce, ne l'est sans doute pas aux autres *Eretmia* qui diffèrent peu entre elles et notamment à la première dans l'énumération. Ce sont des formes à lorica lisse s'effilant en quelques longues épines ; *E. tetrathrix* est figurée étalée avec une organisation de Rotifère. Il est singulier d'ailleurs qu'elles aussi n'aient jamais été retrouvées. Seul à ma connaissance Daday en 1913 (et en 1894 dans un travail hongrois que je n'ai

pas eu sous les yeux) mentionne *E. trithrix* on ne sait pourquoi dans les Notommatidés... Il se pourrait que ce fussent en réalité des Triarthridés en voie d'acquérir une lorica et ayant perdu par suite la mobilité de leurs soies...

Quant à *Kijanebalola*, il n'est pas douteux d'après ce que nous avons dit que ce ne soit un Gastrotriche adapté à la vie pélagique, assez voisin de *Neogossea* mais avec des écailles beaucoup plus développées et suppression des cils ventraux en dehors de la tête. La rétractilité de celle-ci et la différenciation de la cuticule dans un pharynx court créent une convergence d'aspect avec les Rotifères qui n'a rien de particulièrement étonnant. Les trois paires d'organes sensoriels ciliés sont quelque chose de plus remarquable... Il est d'autre part certain, tant par les travaux de Remane sur l'organisation sans doute primitive des Macrodasyoïdes que par le mien sur l'embryologie des Chaetonotoïdes que les Gastrotriches, bien qu'apparentés aux Rotifères, en sont assez éloignés pour qu'on ne puisse s'attendre à trouver une forme strictement intermédiaire entre les deux.

INDEX BIBLIOGRAPHIQUE.

APSTEIN, C. 1907. Das Plankton im Colombo-See auf Ceylon. Zool. Jahrb., Abt. Syst. xxv.

——. 1910. Das Plankton des Gregory-See auf Ceylon. Ibid. xxix.

BARROIS, TH., et DADAY, E. VON. 1894. Contribution à l'étude des Rotifères de Syrie et description de quelques espèces nouvelles. Rev. biol. Nord de la France, vi. Voir aussi Math. Termész. Ertes., Budapest, xii.

BEAUCHAMP, P DE. 1909. Recherches sur les Rotifères : les formations tégumentaires et l'appareil digestif. Arch. Zool. expér. (4) x, et Thèse Sc. Paris.

——. 1930. Le développement des Gastrotriches, note préliminaire. Bull. Soc. zool. France, liv.

——. 1932. Reports on the Percy Sladen Expedition to some Rift Valley Lakes in Kenya.—III. Rotifères. Ann. & Mag. Nat. Hist. (10) ix.

BRYCE, D. 1931. Report on the Rotifera : Mr. Omer-Cooper's Investigation of the Abyssinian Fresh Waters (Dr. Hugh Scott Exped.). Proc. Zool. Soc. London.

COLLIN, A. 1897. Rotatorien, Gastrotrichen und Entozoen Ost-Afrikas (die Tierwelt Ost-Afrika's, xv).

DADAY, E. VON. 1903. Mikroskopische Süsswassertiere aus Kleinasien. Sitzungsber. Akad. Wiss. Wien, cxii, 1.

——. 1907. Plankton-Tiere aus dem Victoria-Nyanza. Zool. Jahrb. Abt. Syst. xxv.

——. 1913. Classis Rotatoria. Fauna Regni Hungariae. Budapest.

FADÉEV, N. N. 1925. Matériaux pour la connaissance de la faune des Rotifères de Russie. Trav. Soc. Natural. Kharkov, 1 (en russe).

HARRING, H. K. 1913. Synopsis of the Rotatoria. Smithson. Inst. U.S. Nat. Mus., Bull. 81.

HEMPEL, A. 1896. Description of new Species of Rotifers and Protozoa from the Illinois River and adjacent Waters. Bull. Illinois St. Lab. Nat. Hist. v.

HUDSON, C. T., & GOSSE, P. H. 1886. The Rotifera or Wheel Animalcules, both British and Foreign. London.

JENNINGS, H. S. 1900. Rotatoria of the United States, with especial reference to those of the Great Lakes. Bull. U.S. Fish Comm. xix.

Manfredi, Paola. 1927. Prima nota intorno [illegible] Mem. i, Supplem. al Boll. di Pesca, Piscic. e Idrobiologia. Roma.

Murray, J. 1906. The Rotifera of the Scottish Lochs. Trans. R. Soc. Edinburgh, xlv.

——. 1913. South American Rotifera.—III. Journ. R. Microsc. Soc.

Neizvestnova-Jadina, E. S. 1924. Das Zooplankton des Oka-Stromes bei Murom. Arb. biol. Oka-St. iii. Murom.

Remane, A. 1926. Morphologie und Verwandschaftsbeziehungen der aberranten Gastrotrichen.—I. Zeitsch, Morph. Ökol. v.

——. 1929. Gastrotricha. Kükenthal u. Krumbach, Handb. der Zool. Berlin u. Leipzig.

——. 1929–32. Rotatorien, 1–3 Lief. Bronn's Tierreich, iv, 2.

——. 1932. Ein neues Rumpfsinnesorgan der Rädertiere. Zool. Anz. xcii.

Rousselet, C. F. 1911. On Three new Species of Rotifera. Journ. Quekett Microsc. Club, (2) xi.

Schmarda, L. K. 1854. Zur Naturgeschichte Aegyptens. Denksch. Akad. Wiss. Wien, mat.-naturw. Kl., vii.

Skorikov, A. S. 1914. Das Plankton des nied. Stromes der Wolga. Trav. Lab. ichthyol. Astrakhan. Moscou.

Wiszniewski, J. 1929. Zwei neue Rädertier-Arten: *Pedalia intermedia*, n. sp., und *Paradicranophorus limosus*, n. sp. Bull. Acad. polon., cl. Sc., B, ii.

Worthington, E. B. 1932. Scientific Results of the Cambridge Expedition to the East African Lakes, 1930–1.—1. General Introduction and Station List. J. Linn. Soc., Zool. vol. xxxviii. no. 258, p. 99.

Scientific results of the Cambridge Expedition to the East African Lakes, 1930–1.—7. The Algae.* By Florence Rich, M.A., F.L.S.

(With 4 Text-figures)

[Read 2 February 1933]

As I had recently examined the Phytoplankton collected by Miss P. Jenkin from the smaller lakes (Naivasha, Nakuru, Elmenteita, and Baringo) of the Kenya (Eastern) Rift Valley I was glad to have the opportunity of examining the Phytoplankton collected by the Cambridge Expedition to the Lakes of Kenya and Uganda, and of comparing and contrasting the two collections. Dr. Worthington first submitted to me thirty tubes of plankton, and later sent me some additional tubes (including a few from Lake Naivasha) containing 'water weeds' with attached algal growth; these later samples proved very useful, as they contained in abundance some of the algae which were but scantily represented in the plankton.

The chief centre of interest was the collection from Lake Rudolf in the desert region of Northern Kenya (bordering on the Sudan and Abyssinia); this was the last of the great African lakes to be discovered (1885), and the large island in the Lake, called Central Island, had never been visited until 1931, when the Cambridge Expedition went there. The algae of this lake have not previously been submitted to examination, though the algae of the other large lakes of East and Central Africa have been fully investigated as the following references serve to indicate :—

Lake Nyasa.—Schmidle, W. (1902) (including Victoria Nyanza); Müller, O. (1903–10); G. S. West (1907).

Lake Tanganyika.—West, G. S. (1907) (this also includes plankton from Nyasa and Victoria Nyanza).

Victoria Nyanza.—Schmidle, W. (1902); Ostenfeld, C. H. (1908); Woloszynska, J. (1914).

Lake Albert.—West, G. S. (1909).

There is also an account by W. and G. S. West of some Algae from Central Africa collected by Dr. J. W. Gregory during an expedition to Mount Kenya in 1893 (Journ. Bot. xxxiv, pp. 377–84).

* From the Botanical Department, East London College, University of London. I am indebted to the Carnegie Corporation for the Advancement of Research for a grant, made through the Research Grant Board of the Union of South Africa, which has aided me in this work.

The Diatoms collected by the Rhodesia–Congo Expedition in 1911–12 were described by S. Erlandsson in 1928 (Svensk Botan. Tids. xxii).

In fact, so much work has been done on these African lakes that there is probably not much new left to discover, and the present paper, apart from minor points, contains but little of interest.

Ostenfeld (1908) remarks that the phytoplankton of Victoria Nyanza and Lake Nyasa bear a great resemblance to each other, the dominant species in both lakes being the same. The former lake was richer in species, this being mainly due to the occurrence of many Desmids.

In the following list a note is added after each species if it has previously been recorded from the above-mentioned lakes—it will be seen how many Algae are common to two or more of them.

In commenting on the phytoplankton of the large African lakes G. S. West (1907) draws attention to the absence of many genera which are dominant features of the European lake-plankton at certain seasons of the year, referring particularly to the genera *Dinobryon*, *Asterionella*, *Tabellaria*, *Rhizosolenia*, and *Coelosphaerium*. Of these, *Coelosphaerium* was found by Ostenfeld (1908) in Victoria Nyanza, and it occurs in the present collection, and *Asterionella* also occurs in the present collection, while *Dinobryon* and *Tabellaria* have been found in the Transvaal. (See Rich, F., 1932.)

Dr. Worthington's collection was made in every month of the year except October; previous collections of phytoplankton from the Great Lakes had been made in the months of February (1908), April (1905), October (1892), and November (1904).

Of the lakes now under consideration the following algae may be looked upon as distinctive features :—

Of Lake Rudolf, *Hormidium subtile* ;

Of Crater Lake A on Central Island, *Rhopalodia gibberula* ;

Of Crater Lakes B and C on Central Island, *Arthrospira platensis* ;

Of Lake Edward, *Surirella biseriata* and *Microcystis flos-aquae* ;

Of Lake George, *Microcystis flos-aquae* and *Synedra* spp ;

Of Lake Bunyoni, *Rhopalodia*, several species ;

Of Lake Nakavali, *Microcystis flos-aquae* and *Melosira granulata*, and var. *angustissima* ; and

Of Lake Kachira, *Microcystis flos-aquae*.

The Desmidiaceae were found to be poorly represented in the plankton of Lakes Tanganyika and Nyasa, but they were said to play a conspicuous rôle in the plankton of Victoria Nyanza. The only lake of this region examined by me in which Desmids were other than very rare was Lake Naivasha. *Staurastrum limneticum* Schmidle, a species of similar type to *S. Ophiura* Lund., which is generally distributed in many lakes in the western areas of the British Isles, was stated to be the most abundant Desmid in the plankton of Victoria Nyanza, but I have not come across it at all. The few Desmids now found indicate that somewhere in these lakes they may be more abundant,

Noteworthy among the Diatoms (Bacillariales) present were the Rhopalodias, which occurred in Lakes Edward, Bunyoni, and Rudolph. The species with asymmetric frustules seem to be confined to the continent of Africa, and have hitherto been recorded only from Lake Nyasa and its neighbourhood. The thick, dichotomously branched stalks of *R. vermicularis* and *R. hirudiniformis* described by Müller (1905, p. 161) are figured for the first time in the present paper. A new form of *R. vermicularis* is described. The Surirellaceae were said to be well represented in the plankton of Victoria Nyanza, Tanganyika, and Nyasa; from Lake Naivasha a form of *Surirella linearis* was figured in 1932 (Rich, F., fig. 3, D.E.), and from Lake Edward various forms of a large and handsome *Surirella* have now been obtained—these forms can all be ascribed to *S. biseriata* or its var. *subconstricta*. Two other Surirellas were observed in Lake Rudolf, one of them, a new variety of *S. biseriata*, was fairly common in the sample taken from open water one mile from the end of Ferguson Spit, but was not observed elsewhere: the other was very rare and was not determined. The species of *Surirella* now found seem to be different from those previously recorded for the great lakes. A new form of *Asterionella gracillima* is figured.

Flagellates (Eugleninae) were present, but in very small quantity only, in Lakes Nakavali and Naivasha. *Ceratium hirundinella*, a Dinoflagellate dominant in the plankton of temperate Europe, and which was present, though of small importance, in the collections from Lakes Victoria and Nyasa, was not found at all in the collection now under consideration.

The Myxophyceae were well represented. By far the commonest alga found was *Microcystis flos-aquae*, which, if we include the allied *M. aeruginosa*, seems to be very widely and abundantly distributed in Africa. The genus *Aphanocapsa* is also very common. Three species of *Anabaenopsis* were observed, two of which appear in previous descriptions to have been confused with one another. Two spirally coiled Lyngbyas have been figured, as, again, there seems to have been some little confusion about them. Some Blue Green Algae that, owing to the state of preservation, could not be fully described have been figured, in the hope that further collections may throw more light upon them.

Several of the algae found have been excluded from the following account owing to the difficulty of identifying them with any degree of certainty, such plants were mostly in a fragmentary condition and some were badly preserved: amongst them were species of *Nostoc* from Lakes Rudolf and Naivasha, and of *Calothrix* from Lakes George, Rudolf, and Nakavali.

Filaments of *Oedogonium*, *Spirogyra*, and *Mougeotia* occurred, but never in the reproductive state, and the species, therefore, could not be satisfactorily determined.

Spiral coiling, a feature of many different species and genera of the phytoplankton, is illustrated here by the occurrence of *Lyngbya circumcreta*, *L. Lagerheimii*, *Arthrospira platensis*, three species of *Anabaenopsis*, and two species of *Spirulina*.

Enumeration of the samples and their most commonly contained species.

Where not otherwise stated the samples are planktonic, obtained with a fine mesh silk plankton net (75 meshes to the centimetre). The numbers of the samples refer to the expedition's station list (Worthington, 1932).

The commonest alga, as a rule, is placed first, the others are in no definite order.

Lake Naivasha.

(As the phytoplankton from this lake has been examined fairly recently (see Rich, F., 1932 *a*), only such samples are referred to here as contained species not previously recorded for Lake Naivasha.)

18. November 1930. *Melosira ambigua, Lyngbya circumcreta, Botryococcus protuberans.*

30. February 1931. 10—5 m. *Melosira ambigua, M. granulata* var. *angustissima, Anabaenopsis tanganyikae, Lyngbya circumcreta, Coelosphaerium minutissimum, Kirchneriella obesa, Aphanocapsa elachista, A. delicatissima, Aphanothece* sp., *Botryococcus protuberans, Scenedesmus obliquus, Staurastrum Dickiei.*

31 (2). February 1931. *Botryococcus protuberans, Mougeotia* sp., *Gomphosphaeria aponina, Phormidium valderianum,* (?) *Anabaena* sp., *Staurastrum Dickiei, Pediastrum tetras.*

39 (2). March 1931. *Nostoc* sp., *Spirogyra* sp., *Gloeocystis gigas, Crucigenia rectangularis, Nephrocytium lunatum, Gloeotrichia natans, Ankistrodesmus falcatus, Phacus pleuronectes, Staurastrum Dickiei* var. *circulare.*

43 (2). May 1931. *Oedogonium* sp., *Coelosphaerium Kützingianum.*

Lake Baringo.

106 A (1). Dec. 1930. *Microcystis flos-aquae, Aphanocapsa Grevillei, Melosira granulata* var. *angustissima, Nitzschia microcephala, Phormidium mucicola, P. autumnale.*

117 (2). Jan. 1931. *Microcystis, Aphanocapsa,* and *Melosira* as above.

121 (2). Jan. 1931. *Microcystis* and *Melosira* as above.

Lake Rudolph.

211 B (1). Dec. 1930. *Arthrospira Platensis* and f. *minor, Hormidium subtile.* This sample was from an enclosed alkaline pool on Ferguson sand-spit ; see also samples 257 and 257 (*a*).

216 (2). Jan. 1931. *Hormidium subtile, Microcystis flos-aquae,* a few diatoms.

220 (5). Jan. 1931. Incrustation on water-weeds. *Lyngbya lutea, Nostoc* sp., *Calothrix* sp. Diatoms.

221 (1). Jan. 1931. Shore-weeds in lee of Ferguson Spit. *Rhopalodia gracilis.*

234 (2). March 1931. *Hormidium subtile.*

248. March 1931. *Hormidium subtile, Phormidium molle, Cyclotella Meneghiniana.*

250. March 1931. *Hormidium subtile, Botryococcus Braunii, Phormidium molle.*

257. March 1931. *Arthrospira Platensis.* Enclosed alkaline pool on Ferguson Spit, see also 211.

257 (*a*). March 1931. Alkaline pool as above. *Anabaenopsis Arnoldii, Arthrospira Platensis, Kirchneriella lunaris, Crucigenia quadrata.*

258 (2). March 1931. *Hormidium subtile, Botryococcus Braunii,* a few Diatoms.

261 (2). March 1931. Similar to last.

266 (3). April 1931. From stomach of fish (*Clarias*). *Phormidium autumnale* and Diatoms (*Gomphocymbella Bruni, Rhopalodia gracilis, R. hiruidiniformis, Gromphonema* sp.).

269. April 1931. Crater Lake B on Central Island. *Arthrospira platensis.*

271 (2). April 1931. Crater Lake A. A good deal of organic débris, *Hormidium subtile, Rhopalodia gibberula, Surirella biseriata* var. *lanceolata, Calothrix* sp., *Rivularia Biasolettiana, Lyngbya lutea.*

273 (2). April 1931. Crater Lake C. *Arthrospira platensis.*

287 (2). April 1931. Water-weeds on west shore covered with a thick incrustation of diatoms. *Rhopalodia hirudiniformis, R. ventricosa, R. gracilis, R. gibberula* var. *rupestris* forma *crassa, Cymbella grossestriata* var. *obtusiuscula, C. helvetica, Gomphocymbella Bruni, Gomphonema intricatum, Cyclotella Meneghiniana, Navicula pupula, N. sphaerophora* var. *rostrata, N. cryptocephala, Nitzschia hungarica.*

Kazinga Channel, Uganda.

510. May 1931. *Microcystis flos-aquae, Aphanocapsa Grevillei.*

527 (1). June 1931. *M. flos-aquae, Pediastrum simplex* var. *radians, Melosira ambigua, Nitzschia microcephala.*

Lake Edward.

528. June 1931. *Microcystis flos-aquae, Pediastrum simplex* var. *radians, Staurastrum* sp.

530 (1). June 1931. *Microcystis flos-aquae, Pediastrum simplex* var. *radians, P. duplex* var. *reticulatum, Dictyosphaerium pulchellum, Tetraëdron minimum* forma, *Staurastrum paradoxum, Botryococcus Braunii, Surirella biseriata* and two vars., *Anabaenopsis tanganyikae, Chroococcus minutus, Lyngbya Lagerheimii.*

542 (3). June 1931. Incrustation on water-weeds. *Rhopalodia hiruliniformis*, *R. gracilis*, *Gomphocymbella Bruni*, *Cymbella* sp., *Lyngbya* sp., *Anabaena* sp., *Microchaeta* sp.

552 (2). June 1931. *Microcystis flos-aquae*, *Surirella biseriata* var. *subparallela*.

571 (1). July 1931. *Microcystis flos-aquae*, *Pediastrum duplex* var. *reticulatum*, *Aphanocapsa Grevillei*, *Staurastrum paradoxum*, *Lyngbya* sp.

571 (7) July 1931. *Microcystis flos-aquae*, *Surirella biseriata* var. *subconstricta*, *Cyclotella Meneghiniana*, *Staurastrum* sp., *Lyngbya* sp.

Kaianda Lagoon.

L. C. Beadle collection, July 1931. *Anabaenopsis circularis*, *A. tanganyikae*, *Aphanothece* sp., *Spirulina subtilissima*, *Cosmarium sexangulare* f. *minima*, *Lyngbya Lagerheimii*, *Rhopalodia gracilis*, *Coelosphaerium Goetzei*, *Merismopedia tenuissima*.

Lake George.

603 (2). July 1931. *Microcystis flos-aquae*, *Pediastrum simplex* var. *radians*, *Aphanocapsa Grevillei*.

617 (6). July 1931. *Spirogyra* sp., *Mougeotia* sp., *Oedogonium* sp., *Closterium Kützingii*, *Synedra ulna* var. *subaequalis*, *S. acus* var. *angustissma*, *Asterionella* sp., *Nitzschia microcephala*, *Rhopalodia gibba*, *Calothrix* sp., *Nodularia spumigena*, *Oscillatoria tenuis*, *Anabaena* 2 spp., *Spirulina major*, *Microchaete* sp.

623 (2). July 1931. *Microcystis flos-aquae*, *Aphanocapsa* sp.

Lake Bunyoni.

707. August 1931. Greyish brown mass on wooden piles along shore. *Lyngbya lutea* forma.

707 A (3). August 1931. Growth on water-weeds on shore. Diatoms together with filaments of *Spirogyra* and *Oedogonium*. (*Rhopalodia hiruduniformis*, *R. vermicularis* forma *recta*, *R. gibba*, and others).

729 (2). August 1931. Stomach-contents of fish (*Tilapia*). *Synedra acus*, *S. ulna*, *Navicula vulpina* (?), *Gomphonema brachyneura*, *G. intricatum*, *Cymbella ventricosa* (?), *Epithemia zebra*, *Rhopalodia gibba*, *R. vermicularis* forma *recta*, *Nitzschia communis* var. *perpusilla*.

Lake Nakavali.

812 (13). August 1931. From weedy shore. Much organic débris. *Scenedesmus protuberans*, *Cryptomonas ovata*, *Cosmarium humile* forma, *Achnanthes lanceolata*, *Melosira granulata* and var. *angustissima*, *Lyngbya circumcreta*, *Microchaete* sp., *Calothrix* sp., ? *Lyngbya* sp.

814 (3). Sept. 1931. *Microcystis flos-aquae, Dictyosphaerium pulchellum, Scenedesmus protuberans, Scenedesmus* sp., *Pediastrum duplex* var. *reticulatum, Coelastrum cambricum* var. *rugosum, Closterium Kützingii, Ankistrodesmus falcatus, Staurastrum* sp., *Melosira granulata* and var. *angustissima, Aphanocapsa elachista* var. *planctonica, A. Grevillei, Merismopedia tenuissima, Coelosphaerium minutissimum, Lyngbya circumcreta, Trachelomonas hispida* forma, *Phacus longicauda* var. *torta, Euglena acus, Gymnodinium* sp., *Phormidium ambiguum.*

Lake Kachira.

824 (2). Sept. 1931. *Microcystis flos-aquae, Melosira granulata, Lyngbya* sp.

Lake Kijanebalola.

833 (2). Sept. 1931. *Microcystis flos-aquae.*

*Systematic enumeration of the species observed.**

(A reference after the specific name is given, except in commonly recorded species, when there is in existence a figure representing the alga observed.)

Class I. ISOKONTAE.

GLOEOCYSTIS GIGAS (Kütz.) Lagerh. West & Fritsch, 1927, fig. 18, G.
Lake Naivasha, from weedy shore, 39. Very rare.
Recorded from Tanganyika and Victoria Nyanza.

PEDIASTRUM SIMPLEX (Meyen) Lemmerm. var. RADIANS Lemmerm.
Kazinga Channel, 527; Lake Edward, 528, 530.
Forms of *P. simplex* abundant in Lake Nyasa.

PEDIASTRUM DUPLEX Meyen var. RETICULATUM Lagerh. Pascher, 1915, v, fig. 57, *h*.
Lake Edward, 530, 571; Lake Nakavali, 814.
Recorded from Victoria Nyanza.

PEDIASTRUM TETRAS (Ehrenb.) Ralfs.
Lake Naivasha, 31.
Recorded for Nyasa, Tanganyika, and Victoria Nyanza.

NEPHROCYTIUM LUNATUM West.
Lake Naivasha, 39.
Recorded for Tanganyika.

TETRAËDRON MINIMUM (A. Br.) Hansg. forma APICULATUM Reinsch.
Lake Edward, 530.
The type recorded for Tanganyika, Albert Nyanza, and Lake Naivasha.

* The system of classification followed is that of West, G. S., and Fritsch, F. E., in 'British Freshwater Algae,' etc. (Cambridge, 1927).

ANKISTRODESMUS FALCATUS (Corda) Ralfs (=*Raphidium falcatus* Corda).
Lake Naivasha, 39 ; Lake Nakavali, 814.
Recorded for Nyasa, Tanganyika, and Victoria Nyanza.

KIRCHNERIELLA LUNARIS (Kirchn.) Möbius.
Alkaline pool, 257.
Cells 8–10 μ across.
Recorded for Nyasa and Lake Naivasha.

KIRCHNERIELLA OBESA (West) Schmidle. Deflandre, 1924, p. 670, fig. 1 (7).
Lake Naivasha, 30 (5–10 metres).
The appearance is that of thick discs incised to a third or half the width of the cell, as described by G. M. Smith, 1920, in the 'Phytoplankton of the Inland Lakes of Wisconsin,' p. 142.
Recorded for Albert Nyanza, Tanganyika, and Victoria Nyanza.

DICTYOSPHAERIUM PULCHELLUM Wood.
Lake Edward, 530 ; Lake Nakavali, 814.
Recorded for Nyasa, Tanganyika, Victoria Nyanza, and Naivasha.

CRUCIGENIA QUADRATA Morren.
Alkaline pool, 257 (*a*), rather common.
Cells about 4 μ.

CRUCIGENIA RECTANGULARIS (A. Br.) Gay (= *Staurogenia rectangularis* A. Br.).
Lake Naivasha, 39, very rare.
Recorded for the neighbourhood of Nyasa.

SCENEDESMUS ARCUATUS Lemmerm. var. PLATYDISCA G. M. Smith, 1920, pl. xxxix, fig. 3.
Lake Nakavali, 814.
Recorded as *S. bijugatus* (Turp.) Kütz. forma *arcuata* (Lemmerm.) W. & G. S. West for Tanganyika.

SCENEDESMUS OBLIQUUS (Turp.) Kütz.
Lake Naivasha, 30 (all depths), in *Dactylococcus* stage.
Recorded for Nyasa, Albert, Tanganyika, and Lake Naivasha.

SCENEDESMUS OPOLIENSIS P. Richter var. CARINATUS Lemmerm.
Lake Nakavali, 814.

SCENEDESMUS PROTUBERANS Fritsch & Rich. 1929, fig. 6, B.
Lake Nakavali, 812, 814.

SCENEDESMUS QUADRICAUDA (Turp.) Bréb. var. BICAUDATUS Hansg.
Lake Nakavali, 814.
The type recorded for Nyasa, Tanganyika, Victoria Nyanza, and Lake Naivasha.

COELASTRUM CAMBRICUM Arch.
Lake Naivasha, 39, very rare.
Recorded for Nyasa, Tanganyika, and Victoria Nyanza.

Var. RUGOSUM Rich in Trans. Roy. Soc. S. Africa, 1932, xx, fig. 3, J.
Lake Nakavali, 814.
First observed in the Transvaal.

HORMIDIUM SUBTILE (Kütz.) Heering (= *Stichococcus subtilis* Klercker).
Lake Rudolf, 211 B, 216, 234, 248, 250, 258, 261, 271 ; Lake Nakavali, 814, very rare.
Not found in samples from the other lakes. A characteristic feature of Lake Rudolf.
Recorded for the Mwangadan River, Central Africa, as *Hormiscia subtilis* (Kütz.) De Toni var. *variabilis* (Kütz.) Kirchn., and for Lake Naivasha.

? MICROTHAMNION STRICTISSIMUM Rabenh.
Lake Naivasha, 39, weedy shore.
As only a mere fragment was observed the determination is not certain.

OEDOGONIUM sp. Vegetative cells 6–7 μ wide.
Sterile material only.
Lake Bunyoni, 707 A.

OEDOGONIUM sp. Vegetative cells, 14–17 μ wide. Sterile material only.
Lake Naivasha, 39, 43 ; Lake Baringo, 106 A ; Lake Bunyoni, 707 A ; Lake Kachira (among Bladder-wort).

SPIROGYRA sp. Width of filament 16 μ. Sterile material only.
Lake George, 617.

SPIROGYRA sp. Width of filament 32 μ. Sterile material only.
Lake Naivasha, 39 ; Lake Edward (N. end ; weeds) ; Lake Bunyoni, 707 A.

MOUGEOTIA 2 spp. Sterile material only.
Lake Naivasha, 31, 39 ; Lake George, 617.

CLOSTERIUM KÜTZINGII Bréb.
Lake George, 617 ; Lake Nakavali, 814, very rare.
Recorded for Nyasa and Lake Naivasha.

COSMARIUM GRANATUM Bréb. W. & G. S. West, 1904–12, ii (1905), pl. lxiii, fig. 3.
Lake Nakavali, 812, very rare.
Recorded for Nyasa and Lake Naivasha.

COSMARIUM HUMILE (Gay) Nordst., forma.
Lake Nakavali, 812. Only one individual observed.
Apex undulate ; no granules seen.
Long. 16 μ ; lat. 14 μ.

COSMARIUM SEXANGULARE Lund forma MINIMA Nordst. W. & G. S. West, 1908, pl. lxxii, fig. 5.
Kaianda Lagoon, Lake Edward, rather common.
Long. 14 μ; lat. 12–13 μ; isthm. 3 μ.
Recorded from Central Africa.

STAURASTRUM DICKIEI Ralfs.
Lake Naivasha, 30.
In shape much more like the published figures of var. *maximum* W. & G. S. West, but the dimensions agree with those of the type.

Var. CIRCULARE Turner. West & Carter, 1923, pl. cxxix, fig. 16.
Lake Naivasha, 39.

STAURASTRUM PARADOXUM Meyen.
Lake Edward, 530 and 571.
Tri-radiate. Long. cell. 26–28 μ; lat. cum proc. 50 μ; isthm. 5 μ.
Recorded for Victoria Nyanza.

Class II. HETEROKONTAE.

BOTRYOCOCCUS BRAUNII Kütz.
Lake Rudolf, 250, 258, 261; Lake Edward, 530.
Recorded for Nyasa, Tanganyika, Victoria Nyanza.

BOTRYOCOCCUS PROTUBERANS W. & G. S. West.
Lake Naivasha, 18, 30 (all depths).
According to Pascher ('Süsswasserflora,' xi, p. 92) *B. protuberans* may be only a stage in development of the preceding species.
Previously recorded for Lake Naivasha.

Class IV. BACILLARIALES.

Group A. CENTRICAE.

MELOSIRA AMBIGUA O. Müll.
Lake Naivasha, 18, 30.
Recorded for Nyasa and Victoria Nyanza.

MELOSIRA GRANULATA (Ehrenb.) Ralfs. O. Müller, 1904, Tab. iii, fig. 6.
Lake Nakavali, 812, 814; Lake Kachira, 824.
Width of cells from 12 to 25 μ.
Recorded from Nyasa, Victoria, and Albert Nyanza.

Var. ANGUSTISSIMA O. Müll.
Lake Naivasha, 30; Lake Baringo, 106 A, 121; Lake Nakavali, 814.
Width of cells 3–4 μ.
Recorded from Victoria Nyanza and Lake Baringo.

CYCLOTELLA MENEGHINIANA Kütz.

Lake Rudolf, 248, 287 : Lake Edward, 571.

STEPHANODISCUS ASTROEA (Ehrenb.) Grun.

Lake Rudolf, 287. Very rare, and identification is a little doubtful. Recorded for the plankton of Nyasa and Victoria Nyanza.

Group B. PENNATAE.

SYNEDRA ACUS Kutz.

Lake George, 617 : Lake Bunyoni, 729.

Cells with a slight constriction in the middle as found in Griqualand West (Fritsch & Rich, Trans. Roy. Soc S. Africa, 1929, xviii, p. 95).

Var. ANGUSTISSIMA Grunow.

Lake George, 617.

SYNEDRA ULNA (Nitzsch.) Ehrenb. var. SUBAEQUALIS Grunow.

Lake George, 617 : Lake Bunyoni, 729.

Recorded for Lake Naivasha.

ASTERIONELLA GRACILLIMA (Hantzsch) Heiberg, forma nov. (Text-fig. 2, C.)

Lake George, 617. Not enough present to admit of a preparation, suitable for detailed examination, to be made.

Differt a typo amplitudine latiore solum.

Length 120 μ ; width 5 μ.

Two freshwater species only of *Asterionella* are known ; the present form approaches one of these (*A. gracillima*) in having the enlargements at both ends of the same size, but it is broader, the shank measuring about 5 μ and the terminal knob 8 μ

Asterionella is a regular and abundant constituent of the plankton of European lakes, but it has not hitherto been recorded in plankton from Africa. One colony was observed in a sample from Natal (Fritsch & Rich, 1924, p. 380) on scum on submerged sand.

ACHNANTHES (MICRONEIS) BIASOLETTIANA Kütz. Meister, Die Kieselalgen der Schweiz, 1912, pl. xiii, fig. 4.

Lake Rudolf, 216 ; Epiphytic on *Surirella biseriata* var. *lanceolata*.

Long. 14 μ ; lat. 6 μ.

ACHNANTHES (ACHNANTHIDIUM) LANCEOLATA Bréb.

Lake Nakavali, 812.

NAVICULA CRYPTOCEPHALA Kütz.

Lake Rudolf, 287.

Long. 26–32 μ ; lat. 6–7 μ. The middle striae shorter than the others.

NAVICULA PUPULA Kütz. O. Müller, 1910, p. 82, Tab. i.

Lake Rudolf, 287.

The few individuals found agreed with Müller's dimensions, save that they were a little wider, 12–13 μ (Müller gives 6·5 to 10·5 μ as the width).

Recorded for Lake Tanganyika.

? NAVICULA SALINARUM Grun.

Lake Rudolf, 216.

Long. 24 μ ; lat. 9 μ. Striae in the middle alternately long and short.

NAVICULA (ANOMOEONEIS) SPHAEROPHORA (Kütz.) Pfitzer var. ROSTRATA Müller, 1899, Tab. xii, fig. 3.

Lake Rudolf, 287.

Long. 42 μ—that is, shorter than the Egyptian variety described by Müller. The type recorded for Lakes Naivasha and Nakuru.

? NAVICULA VULPINA Kütz.

Lake Rudolf, 287 ; Lake Bunyoni, 729.

GOMPHONEMA BRACHYNEURA O. Müll.

Lake Bunyoni, 729.

The striae are shorter than those in the specimens from Natal figured by Fritsch and Rich, *op. cit.* 1924, fig. 30, D.E.

Long. 18–34 μ ; lat. 4–6 μ ; striae in 10 μ circa 10.

Recorded from Nyasa.

GOMPHONEMA INTRICATUM Kütz. Fritsch & Rich, 1929, fig. 6, H.

Lake Rudolf, 287 ; and Lake Bunyoni, 729.

Recorded for Lakes Naivasha and Nyasa.

GOMPHONEMA spp.

Lake Bunyoni, 707 A, and Lake Rudolf, 266. .

GOMPHOCYMBELLA BRUNI (Fricke) O. Müll. (Text-fig. 1, G–I.)

Lake Rudolf, 266, 287 ; Lake Edward, 542.

Found on the western shore of Lake Rudolf attached by slender stalks to water-weeds. The existence of stalks has not before been noted, though from the close resemblance of *Gomphocymbella* to the genera *Gomphonema* and *Cymbella* it must have been inferred ; both long and short dichotomously branched stalks were observed and are shown in fig. 1, G & H. The mid-most of the dorsal striae shows the characteristic stigma composed of more than one punctum ; the adjacent stria (on one or both sides) is shorter. This species is very variable in shape, a fact which is indicated by Müller's two figures (1905, Tab. i, figs. 2 & 3). An occasional abnormal form was observed in sample 287, see text-fig. 1, I.

Long. 38–48 μ ; lat. 10–12·5 μ.

Previously recorded for the neighbourhood of Lake Nyasa.

CYMBELLA GROSSESTRIATA O. Müll. var. OBTUSIUSCULA O. Müll. (1905, Tab. i, fig. 13, and Erlandsson, 1928, xxii, fig. 1, *f*). (The numbers 12 and 13 on Müller's figures should be reversed.)

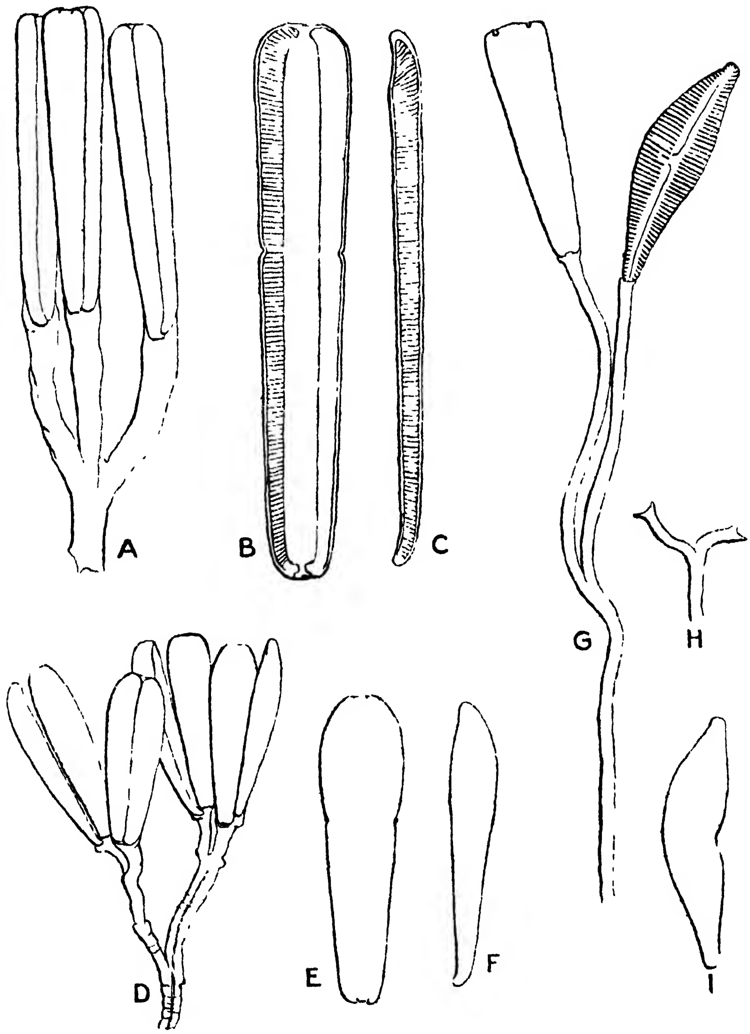
Lake Rudolf, 287.

Long. 25–31 μ ; lat. 8·5–10·5 μ.

Recorded for Uganda and Lakes Nyasa, Tanganyika, and Naivasha.

CYMBELLA HELVETICA Kütz. W. Smith, 1856, ii, pl. ii, fig. 24 *a*.
Lake Rudolf, 287.
Long. 66–67 μ ; lat. 12·5 μ. Striae in 10 μ 12.

TEXT-FIG. 1.



A–C. *Rhopalodia vermicularis* O. Müll. forma nov. *recta*.
D–F. *Rhopalodia hirudiniformis* O. Müll.
G–I. *Gomphocymbella Bruni* (Fricke) O. Mull. I, abnormal form.
A, D, × 100 ; B, C, E, F, × 400 ; G–I, × 750.

? CYMBELLA VENTRICOSA Kütz.
Lake Bunyoni, 729.
Probably this species, but no mucilage-tubes were observed.
Previously recorded for Tanganyika.

EPITHEMIA ZEBRA Ehrenb. var. PORCELLUS Grun. Rich, 1932, fig. 3, A, B.
Lake Bunyoni, 729.
Previously recorded from Lake Naivasha.

RHOPALODIA GIBBA (Ehrenb.) O. Müll.
Lake George, 617 ; Lake Bunyoni, 729.
Previously recorded for Lakes Tanganyika and Kiwu.

RHOPALODIA GIBBERULA (Ehrenb.) O. Müll.
Lake Rudolf, crater lake A on Central Island, 271 (2).
Previously recorded for Nyasa, Tanganyika, and Lake Kiwu.

Var. RUPESTRIS (Grun.) O. Müll. forma CRASSA O. Müll.—a form which approaches *R. musclus* (Kütz.) O. Müll.

Lake Rudolf, 271 and 287. In the latter sample were some very small individuals, only 17 or 18 μ long and 7 μ wide.

Var. VANHEURCKII O. Müll.
Lake Rudolf, 287. The ventral line is straight in the middle.
Long. 18 μ ; lat. 6–7 μ.

RHOPALODIA GRACILIS O. Müll. 1895, p. 63, pl. ii, figs. 5 & 6.
Lake Rudolf, 221, 266, 287 ; Lake Edward, 542 ; Kaianda Lagoon.
Previously recorded for Tanganyika and Victoria Nyanza.

RHOPALODIA HIRUDINIFORMIS O. Müll. (Text-fig. 1, D–F.)
Lake Edward, 542 ; Lake Rudolf, 266, 287 ; Lake Bunyoni, 707 A.

This is one of the Rhopalodias with asymmetric frustules which, so far as is at present known, are confined to the continent of Africa. It occurred as a thick incrustation on the stems of water-weeds in Lake Rudolf. The branched stalks, resembling those of certain Gomphonemas were described by O. Müller (1905, p. 161), but they have not been previously figured. None of the varieties recorded from the Victoria Nyanza were observed in the present collection.

Length of cell 80–140 μ ; greatest width of valve 16–18 μ.
Previously recorded from Nyasa, Victoria Nyanza, and Tanganyika.

RHOPALODIA VENTRICOSA (Grun.) O. Müll.
Lake Rudolf, 287.
Previously recorded for Lake Naivasha.

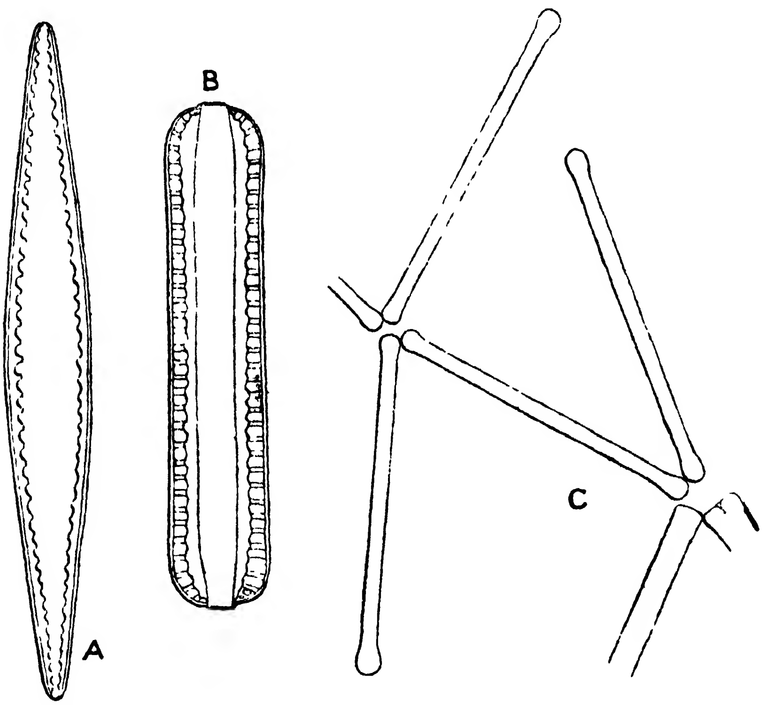
RHOPALODIA VERMICULARIS O. Müll. forma nov. RECTA. (Text-fig. 1, A–C.)
Lake Bunyoni, 707 A, 729.
Margine dorsali valvarum recta, non sinuosa.
In the present form the dorsal contour of the valve is perfectly straight,

not sinuous as in the type (O. Müller, 1895, pl. ii, figs. 10 & 11), but in other respects it agrees with Müller's description. In *Rhopalodia ascoidea* O. Müll. also the contour is straight, but the apex of the valve is curved towards the ventral side, while here it is not so curved. The very thick gelatinous stalks are drawn in text-fig. 1, A.

Length of cell 146–240 μ (200 μ was a very common length): greatest width of valve 18 μ; width of girdle-face 32–38 μ.

Rhopalodia vermicularis was noticed by G. S. West (1907, p. 162) on the lake shore of Karonga Nyasa, forming thick, yellow-brown, matted

TEXT-FIG. 2.



A. B. *Surirella biseriata* var. *lanceolata*. C. *Asterionella gracillima* forma. All ×400.

masses on the back of a beetle (*Limnogeton*). In Lake Bunyoni it was found attached to water-weeds on the shore, intermingled with the far more abundant *R. hirudiniformis*. It was also found here in the stomach of a fish (*Tilapia*).

The type has been previously recorded from Nyasa, Victoria Nyanza, and Lake Kiwu.

NITZSCHIA COMMUNIS Rabenh. var. PERPUSILLA Rabenh.

Lake Bunyoni, 729.

NITZSCHIA HUNGARICA Grun.
Lake Rudolf, 287.

NITZSCHIA MICROCEPHALA Grun.
Lake Baringo, 106 A ; Lake George, 617.

NITZSCHIA sp.
Lake George, 617.

SURIRELLA BISERIATA Bréb. var. VULGARIS Meister.
Lake Edward, 530, very common.
Length 153 μ ; width 42 μ.

Var. SUB-CONSTRICTA Meister.
Lake Edward, 530, 571.
Length 180–300 μ ; greatest width 35–44 μ ; ribs in 10 μ = 1·75.

Var. SUBPARALLELA Meister.
Lake Edward, 530, 552.
Length 280 to 306 μ ; greatest width 40 to 44 μ.

Var. LANCEOLATA, var. nov. (Text-fig. 2, A, B.)
Lake Rudolf, 216, 271.
Longiore quam typo, polis plus attenuatis.
Length 180–300 μ ; width of valve 28–35 μ ; width of girdle 35–44 μ ; ribs in 10 μ = circa 1·6.
This variety is longer than the type and its extremities are more attenuated

SURIRELLA sp.
Lake Rudolf, 287. Only one individual seen.

Class V. CRYPTOPHYCEAE.

CRYPTOMONAS OVATA Ehrenb.
Lake Nakavali, 812.

Class VI. DINOPHYCEAE.

GYMNODINIUM sp.
Lake Nakavali, 814. Very rare.

Class VIII. EUGLENINAE.

EUGLENA ACUS Ehrenb.
Lake Nakavali, 812, 814 ; Kazinga Channel, 527.

EUGLENA OXYURIS Schmarda forma MINOR Deflandre (Fritsch & Rich, 1929, fig. 24, A).
Lake Nakavali, 814. Very rare.

PHACUS LONGICAUDA (Ehrenb.) Duj. var. TORTA forma, as in Griqualand West and Brakpan. Fritsch & Rich, 1929, fig. 25, B–F.
Lake Nakavali, 814.

PHACUS PLEURONECTES (O. Müll.) Duj.
Lake Naivasha, 39.
Previously recorded from Albert Nyanza.

TRACHELOMONAS HISPIDA (Perty) Stein.
Lake Nakavali, 812, 814.
Long. 40 μ.

Class XI. MYXOPHYCEAE.

MICROCYSTIS FLOS-AQUAE (Wittr.) Kirchn.

Lake Baringo, 106, 117, 121; Kazinga Channel, 510, 527; Lake Edward, 528, 530, 552, 571; Lake George, 603, 623; Lake Nakavali, 814; Lake Kachira, 824; Lake Kijanebalola, 833.

This is certainly the commonest alga in the present collection. The colonies are frequently broken through and show gaps, thus resembling the figure of *M. aeruginosa* Kütz. given by G. M. Smith (1920), pl. v. fig. 2. The cells are 3–6 μ in diameter, and frequently possess pseudo-vacuoles. Sometimes, notably in Lakes Nakavali and Kijanebalola, the colonies are lobate, and are enclosed in a firm, well-defined sheath, thereby recalling *M. marginata* (Menegh.) Kütz., but no stratification of the sheath was visible. On the whole, it seems wisest to refer all the forms noticed to the species *flos-aquae*.

Previously recorded from Nyasa and Victoria Nyanza.

MICROCYSTIS MARGINATA (Menegh.) Kütz.

Lake Edward, 571.

Elongated colonies 80–90 μ long, 40–50 μ broad. Cells round, about 5 μ in diameter. Pseudo-vacuoles present. Sheath showing well-defined stratification.

APHANOCAPSA ELACHISTA W. & G. S. West.
Lake Naivasha, 30.
Previously recorded for this lake.

Var. PLANCTONICA G. M. Smith.
Lake Nakavali, 814.

Cells 2–3 μ in diameter. The sheath ill defined. Colonies usually from 40–50 μ across.

APHANOCAPSA DELICATISSIMA W. & G. S. West.
Lake Naivasha, 30; Lake Nakavali, 814.
Cells less than 1 μ in diameter.

APHANOCAPSA GREVILLEI (Hass.) Rabenh.

Lake Baringo, 106 A; Kazinga Channel, 510; Lake Edward, 571; Lake George, 603; Lake Nakavali, 814.

Cells about 5 μ in diameter, frequently in pairs.

The allied *A. pulchra* (Kütz.) Rabenh., which should probably be included in this species, has been recorded from Tanganyika.

APHANOTHECE sp.

Lake Naivasha, 30; Kaianda Lagoon, very rare.

Cells barely 2 μ wide, about twice as long. The few colonies seen come near *A. nidulans* P. Richter.

CHROOCOCCUS MINUTUS Kütz.

Lake Edward, 530, and Kaianda Lagoon.

GOMPHOSPHAERIA APONINA Kütz.

Lake Naivasha, 31.

Previously recorded from Naivasha and Tanganyika.

COELOSPHAERIUM GOETZEI Schmidle.

Lake Edward, Kaianda Lagoon.

Previously recorded for Central Africa.

COELOSPHAERIUM KÜTZINGIANUM Naeg.

Lake Naivasha, 43; Lake Edward, Kaianda Lagoon.

Recorded from Victoria Nyanza.

COELOSPHAERIUM MINUTISSIMUM Lemmerm.

Lake Naivasha, 30; Lake Nakavali, 814.

Cells 1 μ, or less, in diameter.

MERISMOPEDIA TENUISSIMA Lund.

Lake Nakavali, 814; Lake Edward, Kaianda Lagoon.

Found in North, East, Equatorial, and South Africa.

? DACTYLOCOCCOPSIS RHAPHIDIOIDES Hansg.

Lake Edward, 571.

Seen only once, and as no more could be found on repeated examination the determination has not been confirmed.

CALOTHRIX BREVISSIMA G. S. West—a doubtful species—var. MONILIFORMIS Ghose. (Text-fig. 4, C, D.)

Lake Nakavali, 812.

Short lengths of cells, 4 μ wide, occurred singly, or two or three together, in the sheath of an Oscillatoriaceous alga, on the weedy shore of Lake Nakavali. The heterocysts were basal, spherical, and slightly larger than the other cells. It is probably merely a young stage of another species. It shows a certain resemblance to *Proterendothrix scolecoidea* W. & G. S. West, but the trichomes are less tapering.

Previously recorded for Tanganyika and Victoria Nyanza.

CALOTHRIX spp.

Lake Rudolf, 220.

In an incrustation occurring on water-weeds from this lake, there occurred, associated with *Lyngbya lutea*, a *Nostoc* and a *Calothrix*, both in an immature condition, and, at this stage, not determinable. Terminal heterocysts were present in the *Calothrix*, but there were no spores.

Other species of *Calothrix* occurred in a fragmentary condition in Lake Nakavali, 812, in Crater Lake A, 271, and in Lake George, 617.

SCYTONEMA sp.

Lake Rudolf, 271.

Fragments only. Trichomes 9–10 μ wide; filaments 10–15 μ.

GLOEOTRICHIA NATANS (Hedw.) Rabenh. Rich, 1932, fig. 20, A, B.

Lake Naivasha, 39, and from the weedy east shore.

Spore, from 14–16 μ wide; from 56–66 μ long.

Previously recorded from plankton in the Transvaal, Tanganyika, and Victoria Nyanza.

RIVULARIA BIASOLETTIANA Menegh.

Lake Rudolf, Crater Lake A, 271.

Fragments only. Sheaths yellow. Trichome 8 μ wide at base, tapering above to 4 μ.

Recorded for Lake Naivasha.

? MICROCHAETE CAPENSIS Hodgetts. (Text-fig. 4, E–G.)

Lake Edward, 542, from an incrustation on water-weeds.

Filaments 4–5 μ wide, except at the base where they may be 8–9 μ. Trichome about 3 μ, slightly attenuated at the tip. Cells shorter, or a little longer, than broad; terminal cell with a rounded apex. Heterocyst terminal, basal, somewhat egg-shaped, or conical, with the narrower end pointing downwards; 6–7 μ wide, 9–10 μ long. The sheath (which does not turn blue with chlor-zinc-iodide) is prolonged backwards, below the heterocyst, forming a short tube (text-fig. 4, F) or shrivelling to a point (text-fig. 4, E). This appearance may be due to part of the common sheath being dragged away with the filament, but this could not be established in the material to hand.

I place this alga tentatively in the above species mainly on account of the shape of its heterocyst (see Hodgetts, 1925, fig. 16, A, B), but its cells are longer, and no spores were present.

Hodgetts's species was growing on the sides of a glass tank in the laboratory.

? MICROCHAETE UBERRIMA N. Carter f. MINOR N. Carter, 1926, pl. i, figs. 1–4.

Lake Nakavali, 812; Lake George, 617; Lake Kachira on Bladder-wort.

Filaments three or four together, 10–14 μ wide. Trichome about 8 μ wide, cells almost square. Intercalary heterocysts elongated, almost rectangular, 14–22 μ long, sometimes two together. No spores were seen, hence this determination is rather doubtful; the specimen agrees very closely with Carter's figures.

The allied *M. violacea* Frémy has been recorded from standing water in French Equatorial Africa.

NOSTOC spp.

Lake Naivasha, 39; Lake Rudolf, 220; Lake Nakavali, 812.

In Lake Rudolf the species present occurred in small mud-like patches on the stems of higher plants. It was in an immature condition intermingled with *Lyngbya lutea* and a species of *Calothrix*. Cells 4 μ wide, terminal cell bluntly conical; heterocyst spherical, 6 μ in diameter.

NODULARIA SPUMIGENA Mertens.

Lake George, 617, very rare.

Trichome 9 μ wide, no sheath visible. No pseudo-vacuoles. (Var. *vacuolata* Fritsch & Rich has been recorded from Griqualand West and the Transvaal. From Tanganyika three species of *Nodularia* have been recorded, but not the present one.)

ANABAENA spp.

Lake George, 617.

(*a*) With pseudo-vacuoles. Cells 4 μ wide; heterocysts round or elongated, 5–6 μ wide. No spores present.

(*b*) Without pseudo-vacuoles. Cells and heterocysts a little wider. No spores present.

ANABAENOPSIS CIRCULARIS (G. S. West) Wolosz. & Miller, *emend.* W. R. Taylor (=*Anabaena flos-aquae* (Lyng.) Bréb. var. *circularis* G. S. West). West, G. S., 1907, pl. x, fig. 2, *a*, *c*; Taylor, W. R., 1932, pl. xxxix, figs. 5–10. (Text-fig. 3, B, C.)

Lake Edward, Kaianda Lagoon, rare. Also observed in Lake Nakuru, Miss P. Jenkin's samples.

Some doubt exists as to the validity of the genus *Anabaenopsis*, and Professor Bharadwaja *, whose manuscript I have been privileged to see, has recently given reasons for discarding it as a distinct genus, and re-establishing it as a section (as distinct from the section *Euanabaena*) of the genus *Anabaena*. In the present paper, however, I am following Frémy and Geitler in retaining the genus *Anabaenopsis* to include those anabaenoid forms which possess a terminal heterocyst at both ends of the filament.

On examining West's material of the above species from Tanganyika I came to the conclusion that three different algae (two of which are spirally coiled and occur in the samples now under consideration) were included under the one name. After writing the first draft of this paper I found that Professor W. R. Taylor (1932) had already come to the same conclusion, and had named those that were spirally coiled as follows :—

(1) The one with elongated cells as *A. circularis* (in my draft paper I had put this tentatively in a separate species, considering that the name *circularis* should be better retained for the *Anabaenopsis* with almost spherical cells and of which Woloszynska had described a var. *javanica*—a variety, by the way, that previously I had suggested should be considered merely as a *form* †).

(2) The one with almost spherical cells as an African form of *Anabaenopsis Arnoldii* Aptekarj ‡.

The trichomes in the sample from the Kaianda Lagoon are short, spirally wound, making usually one and a quarter turns, though occasionally up to

* 'Annals of Botany,' 1933, xlvii, p. 117 *et seq.*

† Rich, F., 1932 *a*.

‡ The cells in the Tanganyika material were said by West to be either spherical or oblong.

as many as four or five. Cells 4–5 μ wide, elongated, two to four times as long as wide, without pseudo-vacuoles, but with a conspicuous granule in each (see text-fig. 3, B, C). Heterocysts solitary, one at each end of the trichome, circular or, less commonly, elongated, 3–5 μ wide ; also containing one or more granules. Spores intercalary, solitary, ellipsoidal, with thickened walls ; 7–8 μ wide, 10–11 μ long (text-fig. 3, B). The spores were not observed either by West or Taylor.

West mentions the occurrence of the characteristic granule, 'gas-vacuole', but figures it only in the forms with elongated cells (i.e. in *A. circularis* and *A. Cunningtonii* according to Taylor). This alga agrees with West's figures, pl. x, 2 *a* and *c*, though not with *b* and *e*.

Previously recorded for Tanganyika, and present in Lake Nakuru.

ANABAENOPSIS ARNOLDII Aptekarj, forma, 'African form', Taylor (=*Anabaena flos-aquae* (Lyng.) Bréb. var. *circularis* G. S. West). Taylor, 1932, pl. xxxix, figs. 11–14 ; West, 1907, pl. x, fig. 2 *b* ; Rich, 1932 *a*, fig. 5, A–C.

Lake Rudolf, Alkaline pool on Ferguson Spit, 257, very common, associated with *Arthrospira platensis*, but more abundant. This association is similar to that found in Lake Elmenteita.

Width of trichome 8 μ, number of turns of spiral one to six. Heterocysts usually circular and 8 μ in diameter ; sometimes a little longer. Spore 10 μ long, nearly as wide ; Taylor found no spores in his Philippine material. Pseudo-vacuoles were occasionally observed.

It differs from the preceding in (1) the greater width of the cells, (2) their shorter length.

In view of the work of Professor Taylor the species I described in 1932 should be named *A. Arnoldii*, forma.

Previously recorded for Tanganyika and Lake Elmenteita.

ANABAENOPSIS TANGANYIKAE (G. S. West) Wolosz. & Miller. (Text-fig. 3, A.)

Lake Naivasha, 30 ; Lake Edward, 530 ; and Kaianda Lagoon.

Trichome barely 3 μ wide ; heterocyst the same width, 5–5·5 μ long.

In specimens from the Kaianda Lagoon as many as five and a half turns to the spiral were sometimes observed.

Previously recorded for Tanganyika and Lake Nakuru. (In Rich, 1932 (*a*), p. 261, *A. circularis* has also been included under this name.)

SPIRULINA MAJOR Kütz.

Lake George, 617.

Previously recorded for Tanganyika.

SPIRULINA SUBTILISSIMA Kütz. Gomont, 1893, pl. vii, fig. 30.

Kaianda Lagoon.

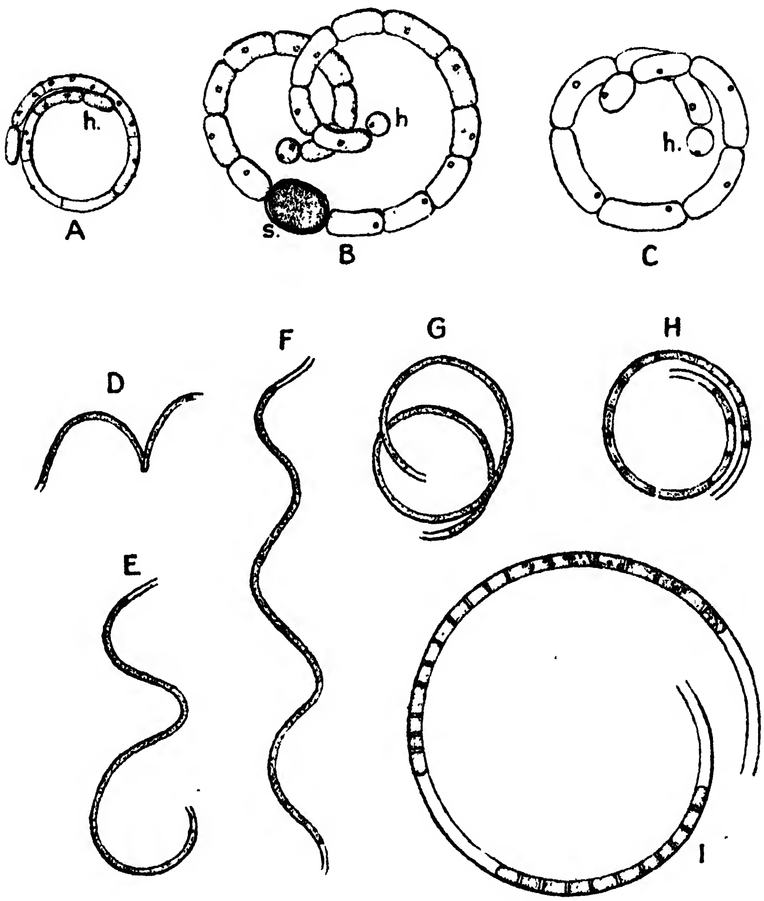
Recorded for Tanganyika.

ARTHROSPIRA PLATENSIS (Nordst.) Gomont (=*Spirulina platensis* (Nordst.) Geitl.) Rich, 1932 *a*, fig. 4, A–F.

Lake Rudolf, 211 B, 257 (*a*) ; Crater Lake B, 269 ; Crater Lake C, 273.

Various forms of spiral were observed, similar to those found previously in Lakes Elmenteita and Nakuru, and the Crater Lake near Naivasha (Rich, 1931, pp. 75–9). The width of the trichome was commonly 6 μ, and the number of turns of the spiral varied from two or three to fourteen. It is noticeable that in the present collection this *Arthrospira* (or *Spirulina*) was found only

TEXT-FIG. 3.



A. *Anabaenopsis tanganyikae*. B, C. *Anabaenopsis circularis*; *h.*, heterocyst; *s.*, spore. D–H. *Lyngbya Lagerheimii*. I. *Lyngbya circumcreta*. All × about 750.

in the alkaline pool on Ferguson Spit, and in crater lakes B and C (all on Lake Rudolf); the alkalinity of these pieces of water was greater than that of Lake Rudolf itself, though less than that of Lakes Elmenteita and Nakuru and Crater Lake.

Forma MINOR Rich, 1932, fig. 4, G, H.

Lake Rudolf, 211 B.

This narrow form, 4 μ wide, occurred sparingly in the above sample. The width of the spiral was about 20 μ, and there were seldom more than five turns to the spiral.

OSCILLATORIA PRINCEPS Vauch.

Lake Naivasha, from weedy East shore.

Width of filament 26 μ.

Widely distributed in Africa; recorded from Albert Nyanza.

OSCILLATORIA TENUIS Ag.

Lake George, 617.

Width 5–6 μ, cells varying in length from 2·5–6 μ, with a slight constriction between. Two rows of granules across the partitions were visible in some individuals. Extremities slightly curved.

Recorded for Victoria Nyanza, Tanganyika, and Albert Nyanza.

PHORMIDIUM AUTUMNALE (Ag.) Gomont.

Lake Baringo, 106; Lake Rudolf, 266.

Recorded for Tanganyika.

PHORMIDIUM AMBIGUUM Gomont, 1893, pl. v, fig. 10.

Lake George, 617; Lake Nakavali, 814.

In the specimens from Lake Nakavali pseudo-vacuoles were observed.

Recorded for Tanganyika.

PHORMIDIUM FOVEOLARUM Gomont, 1893, pl. iv, fig. 16.

Lake Bunyoni, 707 A.

Recorded from Tanganyika.

PHORMIDIUM MOLLE Gomont, 1893, pl. iv. fig. 12.

Lake Rudolf, 248, 250.

It occurs mixed with *Hormidium subtile*.

Width 2–3 μ, cells nearly as long as wide; end-cell rounded.

PHORMIDIUM MUCICOLA Naumann & Huber. Geitler, 1932, fig. 637.

Lake Baringo, 106. Intermingled with disorganized colonies of *Microcystis flos-aquae*.

The filaments are short, generally straight, though sometimes slightly curved, and consist usually of only three or four cells. The cells are barely 2 μ wide, three or four times as long, with rounded ends. At first it was thought that the short filaments observed in this sample were merely the hormogonia of some *Phormidium* growing in the littoral regions, or at the bottom of the lake, but on further consideration they were found to fit in well with the above species.

Not previously recorded for the continent of Africa.

PHORMIDIUM VALDERIANUM (Delp.) Gomont, 1893, pl. iv, fig. 20.

Lake Naivasha, 31.

Not recorded for the Great Lakes of Equatorial Africa, but known from other parts of the continent.

? LYNGBYA HIERONYMUSII Lemmerm.

Lake Edward, 522.

Trichome 14 μ wide; sheath incrusted; cells very short, with granular contents.

This determination is not conclusive, as only a very few filaments were observed.

LYNGBYA LIMNETICA Lemmerm.

Lake Kachira, 824.

Isolated filaments, not more than 2 μ wide; sheath well defined; cells about as long as broad. End rounded. The contents not well preserved.

Recorded from Tanganyika and Victoria Nyanza.

LYNGBYA LUTEA Gomont, forma nov. (*cf.* Gomont, 1893, pl. iii, fig. 13).

Lake Rudolf, 220; Lake George, 617; Lake Edward, 707.

Paullum angustiore quam typo.

On wooden piles along the shore of Lake Edward there was observed a thick, tough, brownish growth, about 1 cm. in thickness, which was found to consist almost entirely of a form of *L. lutea*. The sheath was well defined and stained blue with chlor-zinc-iodide. The apical cell was rounded, and thickened slightly on the outside. In most of the cells there were from one to four relatively large granules. The trichomes were regularly 2 μ wide, of a pale blue colour. The present form is a little narrower than the type, the width of which is given as from 2·5 to 6 μ.

Not previously recorded from the Great Lakes or Equatorial Africa.

Section *SPIROCOLEUS*.

LYNGBYA CIRCUMCRETA G. S. West. (Text-fig. 3, I.)

Lake Naivasha, 30; Lake Nakavali, 812, 814.

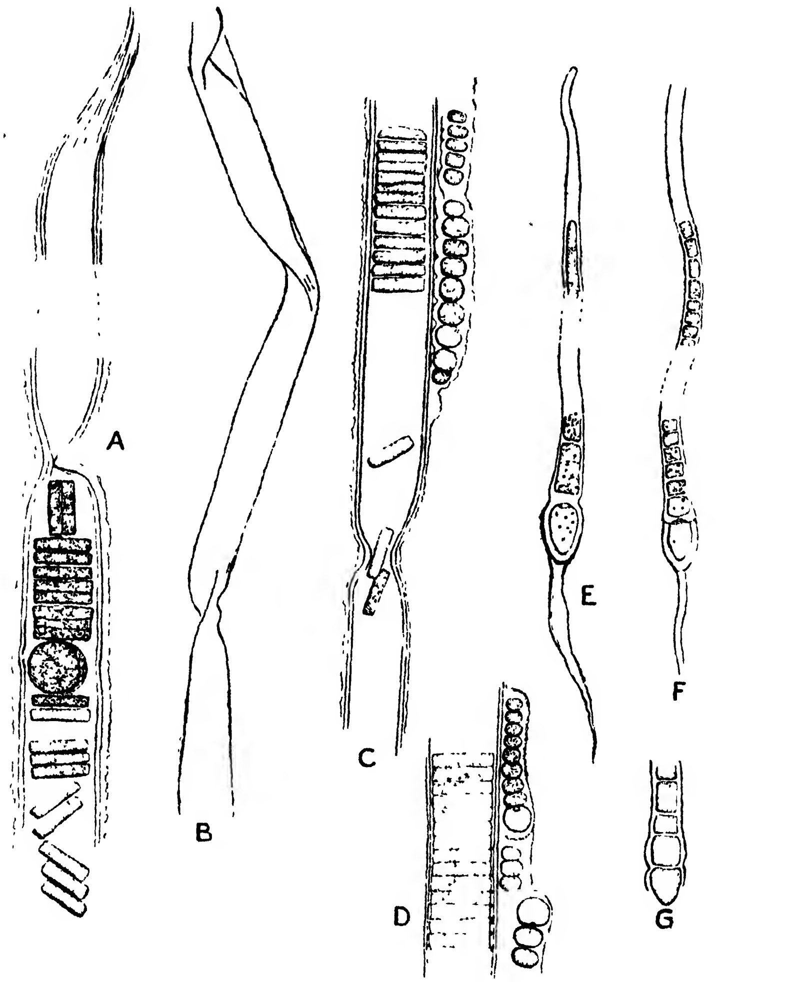
Filaments nearly 2 μ wide, coiled in circles of from 40 to 60 μ in diameter. Cells only a very little longer than broad, apex rounded. At the septa one or two granules are frequently observed, in this respect resembling the spirally coiled *L. bipunctata* Lemmerm., *L. contorta* Lemmerm., and *L. Lagerheimii* Möbius. G. S. West, in his account of the Algae of Victoria Nyanza (1907, p. 174), remarks that the *Lyngbya circumcreta* found by him in this lake comes near *L. contorta*, but differs 'in the hoop-like coiling of its filaments, which are also of greater thickness, and in the much shorter cells.' He does not mention the existence of granules, but I do not find that these are always present. From *L. bipunctata* the *Lyngbya* now under notice differs only in its shorter cells, those of *L. bipunctata* being from 3·5 to 5·5 μ in length. There is evidently some confusion between the species of the spirally coiled Lyngbyas; text-fig. 3, I, makes clear which one is here referred to.

Previously recorded from Victoria Nyanza and Lake Naivasha.

? LYNGBYA LAGERHEIMII (Möbius) Gomont. Ostenfeld, 1908, fig. 2. (Text-fig. 3, D–H.)

Lake Edward, 530, and Kaianda Lagoon.

TEXT-FIG. 4.



Uncertain Blue-Green Algae. A, B. *Lyngbya* sp. (?). C, D. *Calothrix brevissima* var. *moniliformis* in sheath of *Lyngbya* sp. (?). E–G. *Microchaete capensis* (?). All except B ×750.

Filaments in rather small coils or loose irregular spirals. Diameter of coils from 12 to 30 μ. Cells less than 1 μ wide, 2–3 μ long, ends rounded.

This alga differs from the preceding in its smaller coils, and in the possession of narrower and longer cells. It differs from *L. contorta* Lemmerm. in its smaller cells, and the absence of granules. Ostenfeld (1908, p. 333), in describing

the *Lyngbya* found by him in the plankton of Victoria Nyanza, said he considered that both *L. circumcreta* and *L. contorta* should be included in the species *Lagerheimii*, but West (1909, p. 246) did not agree with him, and Geitler (1932, pp. 1043, 1044) still keeps these species distinct. Lemmermann's figures (1898, Tab. v. figs. 10–13) of *L. contorta* are certainly very like the present form, but so also are Ostenfeld's drawings of *L. Lagerheimii* (see above). On the other hand, Gomont's figures (1893, pl. iv, figs. 6 & 7) are not much like it, representing a wider filament. West stated that he was somewhat in doubt about his own determination of *L. contorta* in Lake Albert, but added that in the large African lakes there were two apparently distinct species of spirally twisted Lyngbyas. They are probably the same two that are found in the present collection.

Previously recorded from Victoria Nyanza.

An Oscillatoriaceous alga not well preserved, and therefore not definitely determinable. (Text-fig. 4, A, B.)

Lake Nakavali, 812.

This alga occurred, mixed with a species of *Colothrix*, on the weedy shore of Lake Nakavali.

The filaments present were broken off, and only very rarely was the apex seen (text-fig. 4, A). The material was badly preserved and the cells were often found to be separated from one another by rather large gaps, and were frequently misplaced, lying vertically or obliquely in the sheath (same text-fig.) The filaments, 14 to 20 μ wide, showed many twists and turns (text-fig. 4, B). The sheath was colourless, often rather thick and lamellose, and was drawn out at the apex, where it had a fringed appearance ; it was colourless, and did not turn blue with chlor-zinc-iodide. The trichome was 10–14 μ wide, and the disc-shaped cells were usually only about 4 μ long. The apical cell was rounded. Contents granular.

In many respects this alga showed resemblances to *Porphyrosiphon Notarisii* Kütz., but differed from it in the entire absence of any red coloration, and in its uniformly shorter cells and narrower sheath. Geitler (1932, p. 986) considers that the retention of the genus *Porphyrosiphon* is purely conventional.

The alga now figured may prove to be a *Lyngbya*, but it cannot be properly determined from this material.

Literature cited.

APTEKARJ. 1926. Not. Syst. Inst. Crypt. Horti Bot. Princ. U.S.S.R. iv, figs. 1–8.

DEFLANDRE, G. 1924. Additions à la flore algologique des environs de Paris. Bull. Soc. Bot. lxxi.

CARTER, N. 1926. Freshwater Algae from India. Rec. Bot. Surv. India, ix.

ERLANDSSON, S. 1928. Diatomeen aus Afrika. Svensk Botanisk Tidskrift, Bd. xxii.

FRÉMY, P. 1930. Les Myxophycées de l'Afrique équatoriale française. Caen.

FRITSCH, F. E., & RICH, F. 1924. Freshwater and Subaerial Algae from Natal. Trans. Roy. Soc. S. Africa, xi.

FRITSCH, F. E., & RICH, F. 1929. Freshwater Algae from Griqualand West. Trans. Roy. Soc. S. Africa, xviii.

——, & STEPHENS, E. L. 1921. Freshwater Algae, mainly from the Transkei Territories. Trans. Roy. Soc. S. Afr. ix.

GEITLER, L. 1932. Cyanophyceae (Blaualgen). Leipzig.

GOMONT, M. 1893. Monographie des Oscillariées. Ann. Sci. Nat. Bot. xv & xvi.

HODGETTS, W. J. 1925. Some Freshwater Algae from Stellenbosch. Trans. Roy. Soc. S. Afr. xiii.

HUBER-PESTALOZZI, G., & NAUMANN, F. 1929. Ber. der Deut. Bot. Gesell. xlvii, pp. 67–76.

LEMMERMANN, E. 1898. Forschungsber. d. biol. Stat. in Plon, vi.

MEISTER, F. 1912. Die Kieselalgen der Schweiz. Berne.

MÜLLER, O. 1895. Rhopalodia. Engler's bot. Jahrb. xxii.

——. 1899. Bacillariaceen aus den Natronthalern von El Kab. Hedwigia, xxxviii.

——. 1903–1910. Bacillariaceen aus dem Nyassalande und einigen benachbarten Gebieten. Engler's bot. Jahrb. xxxiv–xlv.

NYGAARD, G. 1932. Freshwater Algae and Phytoplankton from the Transvaal. Trans. Roy. Soc. S. Afr. xx.

OSTENFELD, C. H. 1908. Phytoplankton aus dem Victoria Nyanza. Engler's bot. Jahrb. xli.

——. 1909. Notes on the Phytoplankton of Victoria Nyanza. Bull. Mus. Comp. Zoology, lii, pp. 171–181.

PASCHER, A. 1913 *et seq.* Die Susswasserflora Deutschlands etc. Jena.

RICH, F. 1931. Notes on *Arthrospira platensis*. Rev. Algologique, vi, pp. 75–79.

——. 1932. Phytoplankton from South African Pans and Vleis. Trans. Roy. Soc. S. Afr. xx.

——. 1932 (*a*). Phytoplankton from the Rift Valley Lakes in Kenya. Ann. & Mag. Nat. Hist. x, no. 57, pp. 233–262.

SCHMIDLE, W. 1902. Algen, insbesondere solche des Plankton, aus dem Nyassa See . . . Engler's bot. Jahrb. xxxii.

——. 1902 *a*. Das Chloro- und Cyanophyceenplankton des Nyassa und einiger anderer innerafrikanischer Seen. Engler's bot. Jahr. xxxiii.

SMITH, G. M. 1920. Phytoplankton of the Inland Lakes of Wisconsin. Wisc. Geol. Nat. Hist. Survey, lvii.

SMITH, W. 1856. British Diatomaceae. London.

TAYLOR, W. RANDOLPH. 1932. American Journal of Botany, xix, no. 6, pp. 454–462.

WEST, G. S. 1907. Report on the Freshwater Algae incl. Photyplankton of the Third Tanganyika Expedition. Journ. Linn. Soc., Bot. xxxviii, pp. 81–197.

——. 1909. Phytoplankton from the Albert Nyanza. Journ. of Botany, xlvii, pp. 244–246.

——, & FRITSCH, F. E. 1927. British Freshwater Algae. Cambridge

WEST, W. & G. S. 1896. Algae from Central Africa. Journ. of Botany, xxxiv, pp. 377–384.

—— ——. 1904–1912. A Monograph of the British Desmidiaceae. Ray Society, London, vols. i–iv.

—— ——, & CARTER, N. 1923. *Ibid.* vol. v.

WOLOSZYNSKA, J. 1914. Studièn über das Phytoplankton des Victoriasees. Hedwigia, lv.

WORTHINGTON, E. B. 1932. Scientific Results of the Cambridge Expedition to the East African Lakes, 1930–1.—1. General Introduction and Station List. Journ. Linn. Soc., Zool. xxxviii, p. 99.

Scientific results of the Cambridge Expedition to the East African Lakes, 1930–1.—8. Hydracarina. By Dr. O. LUNDBLAD, Experimentalfältet, Sweden. (Communicated by Dr. E. B. WORTHINGTON, F.L.S.)

(With 13 Text-figures)

[Read 8 December 1932]

SOME time ago, Dr. E. B. Worthington, of Cambridge, forwarded to me a small collection of Hydracarina, collected by his expedition in East Africa. My best thanks are due to Dr. Worthington for the delivery of that interesting material. However, the preservation in alcohol was a serious drawback to the study and the making of microscopic preparations, as the mites had become shrunken and too hard. The best fluid for water-mites consists of 10 vol. glycerin, 9 vol. water, and 1 vol. glacial acetic acid.

The following species were found :—

Family HYDRACHNIDAE.

Genus HYDRACHNA O. F. Müll.

Subgenus MONOHYDRACHNA S. Thor.

1. HYDRACHNA (MONOHYDRACHNA) INAEQUISCUTATA, sp. n.

This interesting little species does not fit well into any of the subgenera hitherto established, the frontal shield being differently shaped according to sex. In this respect the species resembles somewhat *H. mertoni* Walt from the Aru Islands.

Only two specimens, a male and a female, being at my disposal, it seems to me unjustifiable to create a new subgenus until the variation in the shape of the shield could be studied in more material, so I am leaving the species provisionally in the subgenus cited above.

♂.

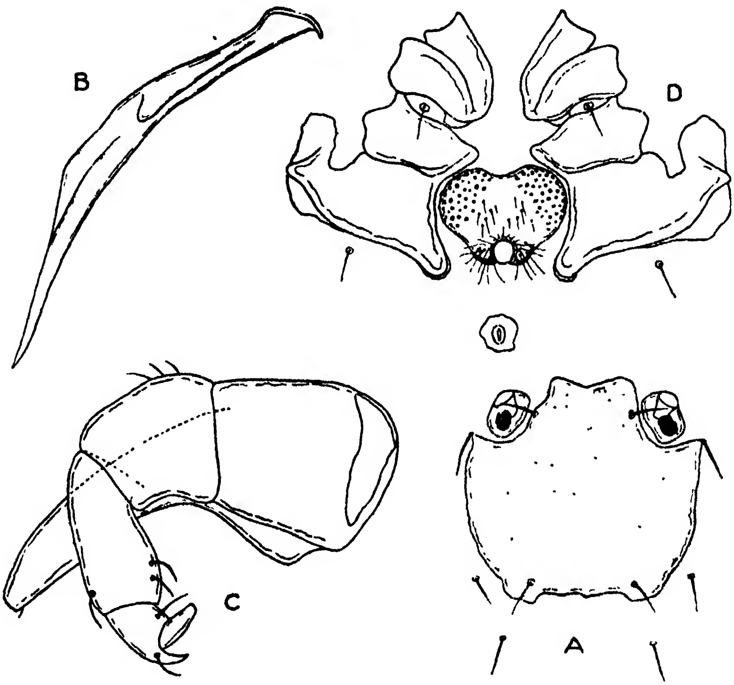
H. inaequiscutata is one of the smallest members of its genus, the male measuring only 790 μ in length. The skin is covered by papillae and the front region bears a single large chitinous plate, which projects forwards between the eye-capsules, ending somewhat in front of these. Laterally behind the capsule the plate forms a sharp corner, which reaches the bristle situated there. The plate is 431 μ broad and 395 μ long. The frontal organ is almost invisible and seemingly strongly reduced.

The measurements for the palp-segments are (in μ) :—

	I.	II.	III.	IV.	V.
Extensor side	125	104	114	64	36
Flexor side	90	54	79	29	25

The palp is rather bulky, with a short and thick 3rd segment. The 2nd segment is likewise short and thick, with the extensor side unusually high and convex, protruding over the upper line of the basal segment. The last-mentioned segment is very characteristic in having the extensor and flexor sides nearly parallel, not diverging towards the base as usua'. The rostrum is relatively short and so are consequently the mandibles, which are 483 μ long.

TEXT-FIG. 1.



Hydrachna inaequiscutata, sp. n. ♂.
A. Dorsal plate. B. Mandible. C. Palp and rostrum.
D. Epimeral and genital plates.

The 4th pair of epimera is provided with a long and narrow inner process, surrounded by a very insignificant subcutaneous border. The border at the articular socket for the 4th leg, on the other hand, is voluminous. It is very important to call attention in the present species to the shape of that border, the anterior margin of which presents a deep bay, because the border does not, as usual, run more or less straight to the 3rd epimeron, connecting the two plates with one another, but is suddenly interrupted, so that the 4th epimeron has a mutilated appearance. The female, though differing in other respects, presents quite the same structure of the epimeral plates, which therefore no doubt is constant and of specific importance.

The epimera 1–3 in the species in question have but small subcutaneous borders. In many other species, however, such borders are larger and I have found them to be very valuable in separating species, though these characters have not yet been used by other hydracarologists.

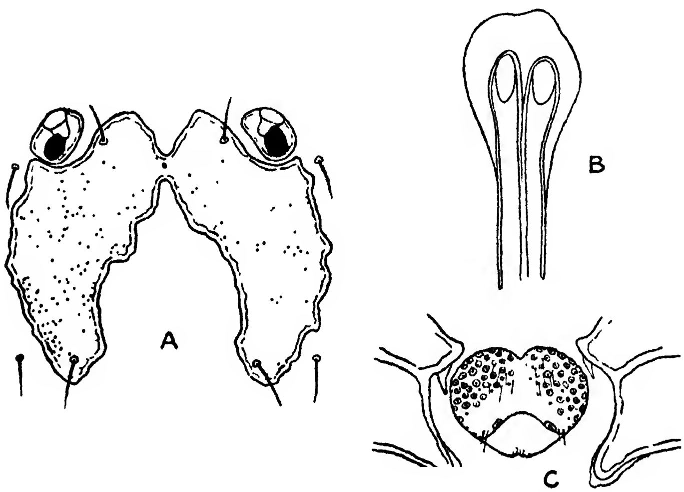
The genital organ is broad and short, bearing but few hairs and few acetabula. The anterior margin is excavated in the middle and the genital opening is rounded and wide.

The small excretory opening lies in a chitinous circular plate.

♀.

The female is larger than the male, measuring about 1200 μ in length. In most characters it fits well the above description of the other sex and will

Text-fig. 2.



Hydrachna inaequiscutata, sp. n. ♀.

A. Dorsal plate. B. Stigma. C. Last pairs of epimera and genital organ.

not therefore be fully described here. For instance, the last epimeron is built up in the same way and the palps agree with those of the male.

The frontal shield, however, differs remarkably in being cleft behind by a very deep bay and in front by a shallow bay, so that only a narrow bridge, including the frontal organ, is left, connecting the two parts of the plates. Thus the plate resembles that of the subgenus *Schizohydrachna* S. Thor. The length of the plate is 483 μ, the breadth of both plates together 569 μ.

The genital organ is heart-shaped, 232 μ broad, 157 μ long, with two large acetabula situated near the posterior margin. The pilosity is very scarce.

Another characteristic is to be found in the opening of the trachea on the

dorsal side of the mandibles. A comparative study of this organ in different *Hydrachna* species has shown me that it is sometimes differently shaped and that it offers important characters for separating species in many cases. Hitherto, however, it has never been used to that purpose. This surely is due to its small size and to the fact that some authors do not make detailed dissections of their specimens.

It is already well known that the two main respiratory tubes in *Hydrachna* run parallel to each other during the last part of their course, being glued close together (text-fig. 2, B), each of them ending in a stigma, closed by a membrane. The shape of this stigma varies from species to species, being short-oval in the one here described.

Locality.—Uganda: Lake Nakavali, from *Papyrus* along shore.

Type (♂) and allotype (♀) in the British Museum.

Subgenus RHABDOHYDRACHNA Viets.

2. HYDRACHNA (RHABDOHYDRACHNA) BISIGNIFERA Viets f. WORTHINGTONI, forma nov.

There are several species of *Hydrachna* with rudimentary dorsal plates occurring in East Africa: viz. *H. spinosa* Koen. from Zanzibar (1893, p. 43), *H. fissigera* Koen., and *H. signata* Koen. from Majunga and Amparangidro in Madagascar (1898, p. 394), *H. dividua* Walt. from Algeria, Tunisia, and Morocco, *H. rimosa* Walt. from Algeria (Walter, 1925, p. 196; 1929, p. 287), and *H. bisignifera* Viets from German East Africa (Viets, 1913, p. 408).

It is rather difficult to separate these species at present. *H. fissigera* Koen. and *H. rimosa* Walt. seem to be extremely nearly related, perhaps identical. The descriptions of some of the other species, e.g. *H. spinosa*, are very unsatisfactory and for the most part give characters common to all *Hydrachna* species and of no specific value.

In Dr. Worthington's material there is a species of *Hydrachna*, which I have identified as *H. bisignifera* Viets, of which the female only was known. The agreement is very good. I have been able to compare the material with the type-specimen, thanks to the courtesy of Dr. K. Viets.

Some drawings and measurements from the Worthington material, which is treated as a special form of Viets's species, may be submitted here.

♂.

This sex has a length of about 1940 μ. The skin is covered with numerous papillae, the shape of which varies from rounded to pointed. The papillae in the anterior part of the body are blunt, those in the posterior part partially pointed.

There are no real dorsal plates, but at a distance behind the eye-capsules a little longer than that between the right and left capsule we find two small plates, serving as muscle-attachments, and in the middle between these and the eyes there are two still smaller chitinous points.

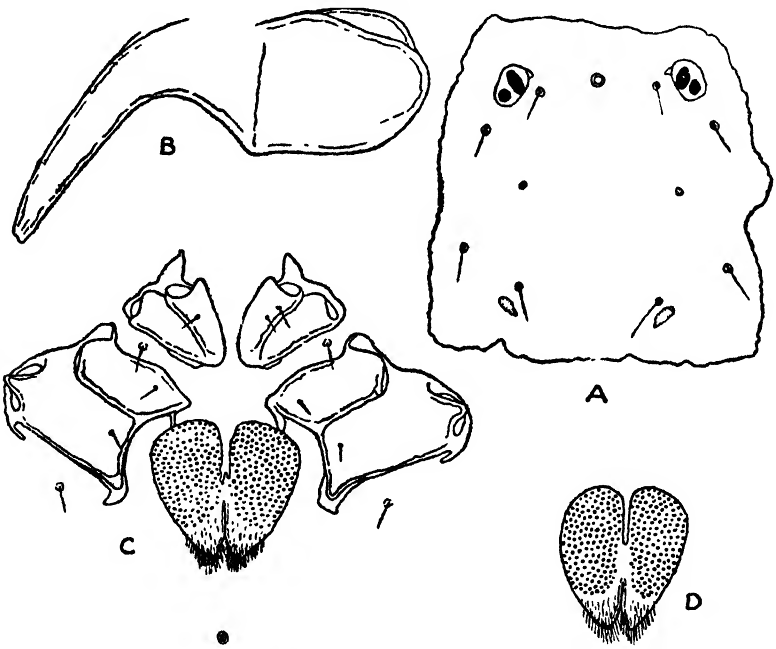
The measurements are (in μ) :—Distance between eye-capsules 470 ; distance between eye-capsules and dorsal plates 655 ; distance between dorsal plates 448.

The palps are much more slender than in the foregoing species. The length of the segments is (in μ) * :—

	I.	II.	III.	IV.	V.
Extensor side	179	232	254	121	54
Flexor side...........	161	114	196	54	46

The mandibles are 965 and the maxillary organ 776 μ long. The shape of the stigma differs considerably from that already described in the preceding species.

TEXT-FIG. 3.



Hydrachna bisignifera Viets f. *worthingtoni*, forma nov. ♂.
A. Frontal region. B. Rostrum. C. Epimeral and genital plates
D. Genital plate of another specimen.

The epimeral field is not quite as broad as in the type-female, measuring only 1845 μ in breadth and 1034 μ in length. The hind corner of the 4th plate is but slightly prolonged backwards, and surrounded by a small subcutaneous border of various shape.

* The extensor side of first segment is not measured in its full length, only from the distal end to that point near the base, where the inner and outer walls of the segment meet. Thus it is not measured to the very base.

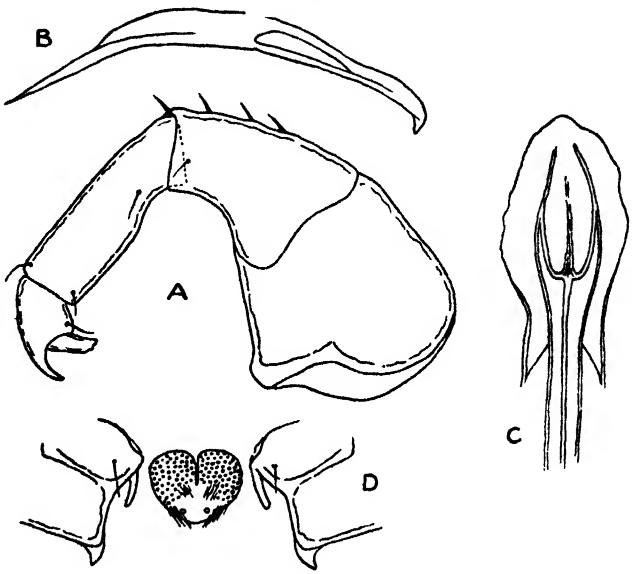
The genital organ is very large (length about 534 μ) and extends halfway outside the genital bay. In front, as well as behind, the organ is divided by a long split, approaching the centre of it. The pilosity in the posterior part is rich and the acetabula are small and numerous. The shape of the organ varies a little in different specimens, sometimes it is broader, sometimes narrower (text-fig. 3, C–D).

The excretory opening lies in a small chitinous ring.

♀.

The body measures 2015 μ in length, the epimeral field 1862 μ in breadth and 1052 μ in length. The genital organ is, as in the male, split up in front, but is considerably smaller, occupying only the anterior half of the genital

TEXT-FIG. 4.



Hydrachna bisignifera Viets f. *worthingtoni*, forma nov. A ♂, B–D ♀.

A. Palp. B. Mandible. C. Stigma. D. Last pairs of epimera and genital organ.

bay. It is 379 μ broad and 276 μ long, agrees well with Viets's figure, and is provided with a large number of small acetabula. Near the posterior margin there are two larger ones. The pilosity is rather limited.

In most other respects the female resembles the other sex. The female differs from the type in having the inner margins of the 4th pair of epimera diverging backwards. In Viets's type-female the genital bay is narrowed in the posterior part by the end of the 4th epimera, which projects considerably towards the centre. This is even more marked in the type than in Viets's drawing.

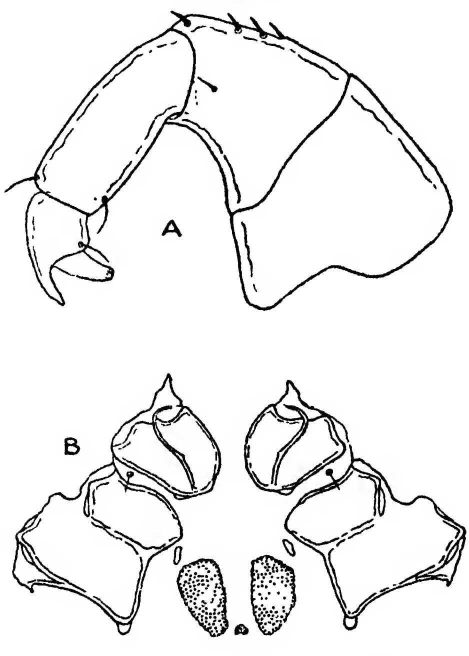
Nymph.

The nymph of the type-form is not yet described. Among the adults there were some nymphs, which no doubt belong to this species and which may be briefly described here.

The nymph is a bit smaller than the adults, measuring about 1550 μ in length. The structure of the skin, the front region, and the stigma does not differ from that of the adults. The palps, however, are much stouter. The measurements are as follows (in μ) :—

	I.	II.	III.	IV.	V.
Extensor side	129	154	175	100	50
Flexor side...........	104	96	121	43	39

TEXT-FIG. 5.



Hydrachna bisignifera Viets f. *worthingtoni*, forma nov. Nymph.
A. Palp. B. Epimeral and genital plates.

Especially the 2nd and 3rd segments are shorter and thicker.

The mandibles attain a length of 707 μ.

The epimeral field resembles that of the adults and reaches a width of 1448 μ. The 4th epimeral plate has a short process bearing a small subcutaneous tongue of chitin. The subcutaneous projection from the 3rd plate lies free in the genital bay ; it is not connected with the plate in question.

The genital plates are separated from one another and bear numerous small acetabula. In the soft skin between them there is a central chitinous muscle-attachment. The ring around the excretory opening is very thin.

Localities.—Uganda: Lake Nakavali, from *Papyrus* along shore and from shore-weeds. Lake Edward, from swamp by shore.

Type (♂) and allotype (♀) in the British Museum.

Genus Bargena Koen.

3. Bargena mirifica Koen.

Bargena mirifica Koenike, 1893, p. 47; Koenike, 1895, p. 4; Piersig, 1901, p. 34; Viets, 1916, p. 247.

This species was described by Koenike from a single male specimen from Zanzibar. Later Viets completed our knowledge by correcting some inaccuracies in Koenike's description and adding some few characteristics from the other sex, which was found among some specimens from the Cameroons. Besides these two records nothing, so far as I know, has been brought to our knowledge concerning this interesting mite, which is still imperfectly known. The present material enables me to discuss some points in the morphology, which needs to be once more elucidated. Male, female, and nymph are represented.

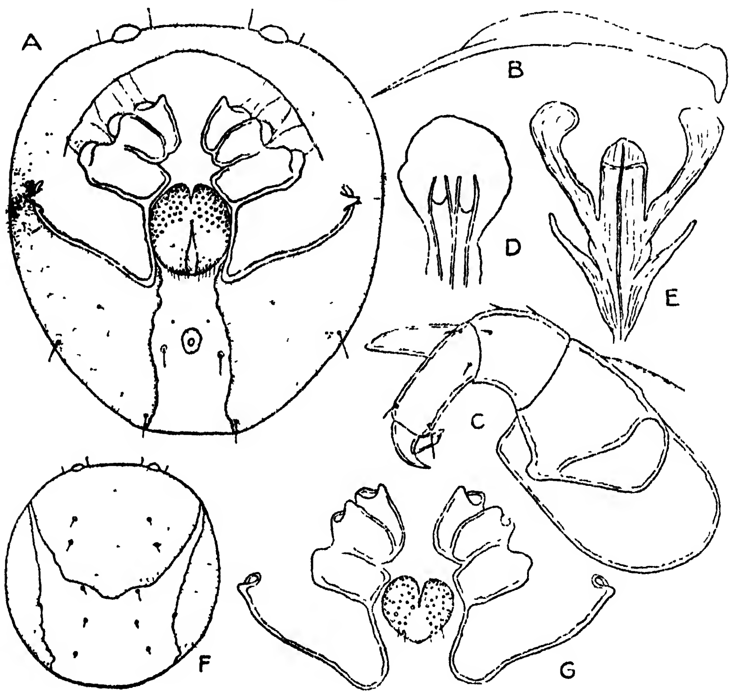
♂.

The body attains a length of 990 μ, a width of 914 μ. The skin is covered by papillae, which are clearly visible only where the skin is soft. The greater part of the body, however, is strongly chitinized, as pointed out already by Koenike. The chitinous armour is mentioned by Koenike (1893, p. 48) in the following way:—'Der Rückenbogen befindet sich auf der hinteren Hälfte der Oberseite und ist vorn offen. Hinten entsendet er, was in ähnlicher Weise noch bei keiner bekannten Hydrachnide beobachtet wurde, zwei Ausläufer, die, anfänglich 0·25 mm. von einander entfernt, sich allmählich einander nähern, indem sie sich am Hinterende des Körpers herabziehen, um beim Umbiegen nach der Bauchseite zusammen zu treffen. Sie begrenzen mit dem dazu gehörigen Teile des Rückenbogens ein glockenförmiges Stück des Hautpanzers.'

As to the 'Rückenbogen' it must be noted that this is not comparable to the 'Rückenbogen' or dorsal groove in *Arrhenurus* or *Frontipoda*, for instance. In reality there is a narrow strip of soft skin along the circular posterior border of the large frontal plate in *Bargena*, and this strip ends blindly on each side in front. Towards the back, however, the two strips coalesce, and then the single strip widens, curving backwards, downwards, and, lastly, forwards on the ventral side to the genital organ. Text-fig. 6, A, shows this 'groove' on the ventral side of the male; on the dorsal side it is about twice as broad.

The 'glockenförmige Stück,' mentioned by Koenike, is not at all developed in the specimen studied by me, so I suppose that Koenike has made a mistake in this respect. He remarks also that he could not trace any excretory opening, and this declaration makes it probable that his specimen was not dissected, so that he was unable to see the opening, which otherwise is very easily visible (see text-fig. 6, A), lying in the soft skin, surrounded by a ring of chitin. The width of the 'glockenförmige Stück' (see Koenike's figure) agrees well with the width of the strip of soft skin in my specimens. Perhaps the borders

TEXT-FIG. 6.



Bargena mirifica Koen. A–E ♂, F–G ♀.

A. Mite from beneath. B. Mandible. C. Palp and rostrum. D. Stigma. E. Penis. F. Mite from above (less magnified). G. Epimeral and genital plates.

of this strip were creased so as to resemble narrow strips of soft skin (' Rückenbogen '). It is very likely that Koenike has been deluded by the preparation not being transparent. Viets does not say anything about this character.

Of course, the non-chitinized parts of the skin are partially homologous to the dorsal groove in *Frontipoda*, for instance, inasmuch as in both cases we find the subcutaneous borders of the 4th epimera much enlarged, curving laterally and dorsally, and approaching each other in the mid-line of the dorsum. In *Frontipoda*, however, there is only a narrow space left, forming a real dorsal

groove, whereas in *Bargena* the space in the male is too wide to be called a groove, and still more so in the female (see below). Moreover, in *Frontipoda* there is no frontal plate, and therefore there is nothing to correspond with the anterior, more or less groove-like strips of *Bargena*, which are situated between the epimeral plates and the frontal plate. A glance at the drawing of the female (text-fig. 6, F) at once makes this intelligible. Undoubtedly the anterior plate in *Bargena* is homologous to the frontal plate in the subgenus *Monohydrachna*. As a matter of fact, *Bargena* differs but little from *Hydrachna*, of which we already know a species having the greater part of the skin armoured with a large shield (*H. junodi* Walter, 1924).

On the ventral side of the body there is a semicircular line between the eyes and the epimera. This line represents the posterior ventral limit of the anterior or frontal shield, in which the eyes are enclosed. Behind this limit the epimera of the pairs 1–3 are embedded in the soft skin. From each of them, however, a sidewards projecting subcutaneous piece of chitin is to be found, but these pieces can be seen only in thoroughly cleaned preparations.

The eyes are situated 293 μ from one another and are very prominent. Their structure could not be investigated in the present material, which is unfortunately preserved in alcohol. No median eye could be detected.

The width of the epimeral field in the region of the 4th plate measures 845 μ. The epimera of the pairs 1–3 are very small and the hind corner of the 4th plate projects much less than in Koenike's figure. The genital organ is large, occupying the whole bay between the 3rd and 4th epimera. It is 193 μ broad and 218 μ long. The genital opening forms a long split along the median line of the posterior half of the organ, and the anterior portion of the opening is very narrow. The anterior margin of the organ is angularly incised in the middle. The pilosity is restricted to the hind part.

The occurrence of a penis evidences that the present specimen is a male. It is of usual form, attaining a length of 190 μ and a width to the anterior larger processes of about 161 μ.

On each side of the excretory opening there is a small piece of chitin, lying in the soft skin and bearing a hair and the opening of a gland.

According to Koenike the maxillary organ has no rostrum and the mouth is said to be placed behind the anterior end of the organ. The mandibles were not dissected out by Koenike. Viets, however, found in his female specimens a well-developed rostrum exactly as in *Hydrachna*, with the mouth at the very tip and the mandibles of the same structure as in *Hydrachna*. I agree fully with Viets that Koenike must have had a mutilated male specimen before him and that Viets's specimens are females.

The rostrum is a normal *Hydrachna*-rostrum and the maxillary plate, when seen in side-view, forms a right angle in front, where it passes over into the rostrum. The maxillary organ (incl. rostrum) is 382 μ long, and the rather strongly curved, robust, and sharply pointed mandibles are considerably longer, viz. 517 μ.

The measurements for the palps are (in μ):

	I.	II.	III.	IV.	V.
Extensor side	125	105	118	57	36
Flexor side...........	71	54	75	46	25

The palp is a real *Hydrachna*-palp and the attachment of the basal segment to the maxillary organ is quite the same as in that genus, having the medial side of the basal segment considerably the longer, reaching further backwards than the lateral one (cf. text-fig. 6, C).

It is also worth mentioning that the structure of the stigma is the same as in *Hydrachna*.

The legs also recall those of *Hydrachna*. A characteristic feature, often mentioned for *Hydrachna*, is that the 3rd segment of the three anterior legs is shortened, but I wish to point out here that this applies also to the 4th leg. Though it is not so obvious here, the 3rd segment of the 4th leg is somewhat shorter than the 2nd and 4th. This peculiar structure holds good also for *Bargena*.

♀.

The body reaches 1206 μ in length and 1120 μ in breadth. Besides the larger size it differs from the male in having a less-developed armour, as already mentioned above. The ventral strip of soft skin, extending from genital organ to end of body, is much broader than in the male, and widens considerably backwards, measuring only 138 μ between the inner ends of the 4th epimera, whereas it is 517 μ broad at the end of the body. On the dorsal surface the soft-skinned region widens still more, measuring 724 μ at the widest place (text-fig. 6, F). Therefore it is fictitious to speak of a dorsal or ventral groove in the female. Viets, who also had some females before him, did not object to that expression of Koenike *, and if we look at Viets's drawing of the female (1916, pl. i, fig. 3 *a*) we will be able to see a rather narrow ventral furrow, for which the name groove seems to be quite adequate. However, the appearance figured by Viets is probably due to shrinking of the mite in consequence of the preservative. This part of the skin being soft, it is also possible that the shape of the mite varies with the distention of the intestines. The female which I have studied, and which was preserved in alcohol, was also shrunk, but was easily restored to its original shape by means of careful preparation.

The process of the 4th pair of epimera is much stouter than in the male. The genital organ is heart-shaped and deeply split up in front and the pilosity is still more scanty than in the male.

The eggs are oval as in *Hydrachna*, 172 μ long and 121 μ broad. Beyond doubt this shape indicates that the *Bargena* female pierces the tissue of plants with her rostrum, boring a hole by means of the mandibles.

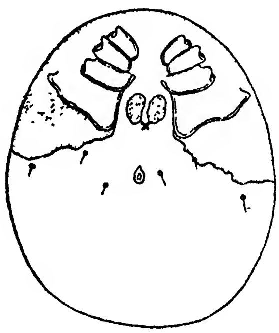
* As already mentioned, Koenike had only a male available, but neither for this sex the expression is a good one (see above).

Nymph.

The nymph has not hitherto been described. It reaches a length of 1120 μ and resembles the adult mite, except that the subcutaneous borders around the 4th epimera reach the sides of the body only, not extending dorsally, and that the provisional genital organ is divided into two lateral parts. The frontal plate is well developed and large. The excretory opening is surrounded by a ring of chitin.

It is curious that Koenike was unable to find the excretory opening in *Bargena*, which is easily visible in both adult and nymph. This seems to confirm my opinion set forth above that Koenike had not dissected his material. Judging from his drawing, Viets has seen the opening (1916, pl. i, fig. 3, *a*), but he does not mention it.

TEXT-FIG. 7.



Bargena mirifica Koen. Nymph from beneath.

Systematic affinities.

The genus *Bargena* comes very near to *Hydrachna*. Characters common to both are: shape and arrangement of epimera, shape of maxillary organ, palps, mandibles, stigma, scope of sexual dimorphism, shape of eggs, bipartite genital organ in the nymph.

The only real difference is the absence of the frontal organ, which, as a matter of fact, sometimes is very feeble also in *Hydrachna*. Perhaps there is also another difference, viz. the organization of the lateral eyes. According to Koenike this is the case, but unfortunately I was not able to verify his statement in my material because of the state of preservation. Until the two characters just mentioned have been carefully examined, it cannot be decided whether they are satisfactory or not for separating the genera. At any rate, the strongly developed armour in *Bargena* is scarcely of any generic importance (cf. the different species of *Lebertia*).

Localities.—Uganda: Lake Nakavali, from *Papyrus* along shore; Lake Kachira, from shore-weeds.

Family HYDRYPHANTIDAE.

Subfamily HYDRYPHANTINAE.

Genus GEORGELLA Koen.

4. GEORGELLA INCERTA (Koen.).

Hydryphantes incertus Koenike, 1893, p. 40; Koenike, 1895, p. 4; Koenike, 1898, p. 388; Piersig, 1901, p. 63.
Georgella incerta Koenike, 1907, p. 129.
Hydriphantes incertus Daday, 1910, p. 584.
Georgella incerta Daday, 1910 *a*, p 239; Viets, 1916, p. 245; Viets, 1921, p. 421.

As in *Hydryphantes* and related genera the frontal shield is sometimes deformed. In one specimen the left half of the shield was separated from the right one, and the frontal organ was connected only with the latter.

The alcohol material of this species was too badly preserved to allow any closer study.

Localities.—Uganda: Lake Nakavali, from *Papyrus* along shore. Lake Kachira, from shore-weeds.

Family DIPLODONTIDAE.

Genus DIPLODONTUS Dug.

5. DIPLODONTUS DESPICIENS (O. F. Müll.).

This common species has been recorded from Europe, Africa, Asia, and America, and probably has a cosmopolitan distribution. There are some other species and varieties described, for instance *Diplodontus despiciens capensis* Viets from South Africa (Viets, 1914, p. 335), *D. tenuipes* Koen. from Java (Koenike, 1906, p. 129), *D. peregrinus* Koen. from Brazil (Koenike, 1905, p. 696), *D. perreptans* Viets and *D. trigonometricus* Walt. from the Cameroons (Viets, 1913, p. 14; Walter, 1927, p. 625), and *D. americanus* Marsh. from N. America (Marshall, 1926, p. 33). At least some of these seem to come very near to *D. despiciens*. Whether they actually are different species is difficult to decide. Some slight differences are described, but as long as the variation within *D. despiciens*—the genotype—has not been studied thoroughly, for instance in connection with sex, much stress cannot be laid upon the interpretations so far. One of these forms, *D. americanus*, has already been withdrawn by the author herself (Marshall, 1929, p. 69).

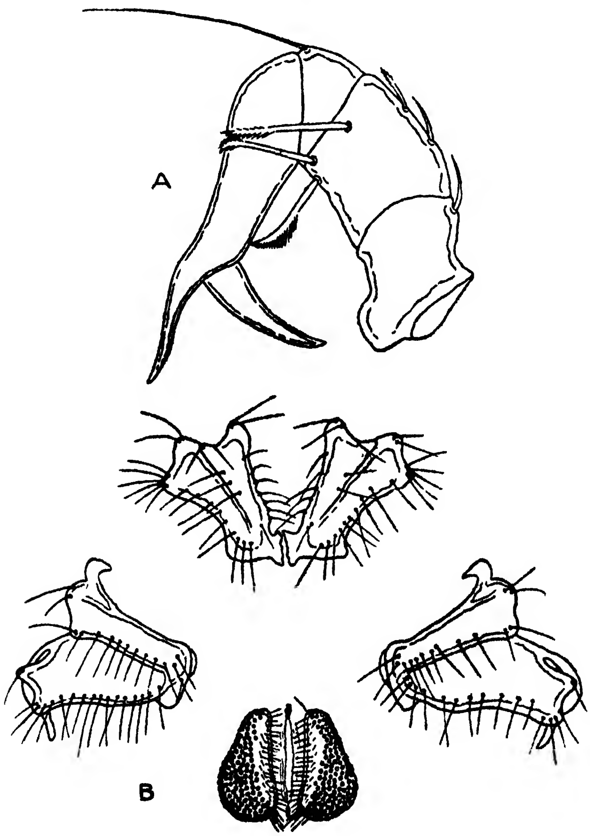
In Dr. Worthington's material *Diplodontus* is represented by some specimens which I refer to *despiciens*, and which may be delineated and shortly described here.

The second palp segment bears the three usual characteristic bristles, all of which are distinctly pectinated *. The pectination is long. So far

* In the drawing the intermediate bristle is somewhat bent out of ordinary position.

as I can see, the most ventral bristle is constantly curved at the end and the pectination is one-sided only. However, I am well aware of the fact that the aspect of the bristles in various mites often depends upon and changes with the point of observation, and though seemingly being one-sided in the specimens

TEXT-FIG. 8.



Diplodontus despiciens (Müll.). ♀.
A. Palp. B. Epimeral and genital plates.

investigated by me I do not venture to deny absolutely the possibility of the pectination being two-sided. The 4th palp-segment is undulated as in the European *despiciens*. Measurements for the palp-segments are difficult to obtain with accuracy, because the segments are so crowded together and have both sides differently shaped. The maxillary organ has a length of 278 μ.

The epimeral plates are relatively short, but I have found that this property varies in our European species. The posterior ones attain a length (i.e. from

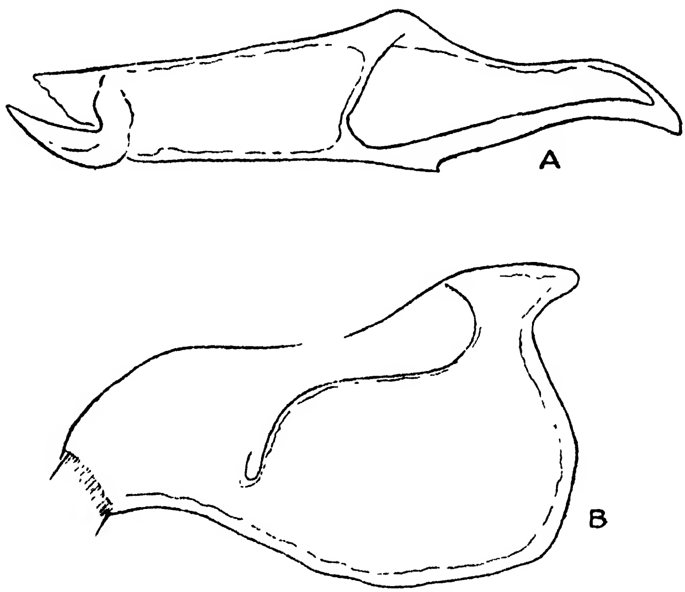
the front backwards)* of 397 μ, a width (i.e. from the lateral projection towards the median border) of 379 μ. The length of the genital plates is 232 μ.

The excretory opening is provided with a ring of chitin. The 4th segment of the last pair of legs bears 11, the following segments 7 swimming hairs. The claws in all legs have a thin dorsal tooth.

The specimen here described is a female, the egg measuring 146 μ.

Locality.—Uganda: Lake Nakavali, from *Papyrus* along shore and from shore-weeds.

TEXT-FIG. 9.



Diplodontus despiciens (Müll.). ♀.
A. Mandible. B. Maxillary organ.

Family LIMNESIIDAE.

Genus LIMNESIA C. L. Koch.

6. LIMNESIA ASPERA Koen. subsp. MACROPORA Viets.

Limnesia aspera subsp. *macropora* Viets, 1921, p. 422.

Of this species the female only has been described, and in the present material that sex alone was represented. It agrees very well with Viets's description.

Localities.—Uganda: Lake Bunyoni, from weedy shore. Kenya Colony: Lake Naivasha, from weedy shore.

* The subchitinous processes before and behind the plates being included.

Family HYGROBATIDAE.

Subfamily PIONINAE.

Genus PIONA C. L. Koch.

Subgenus PIONA, s. str.

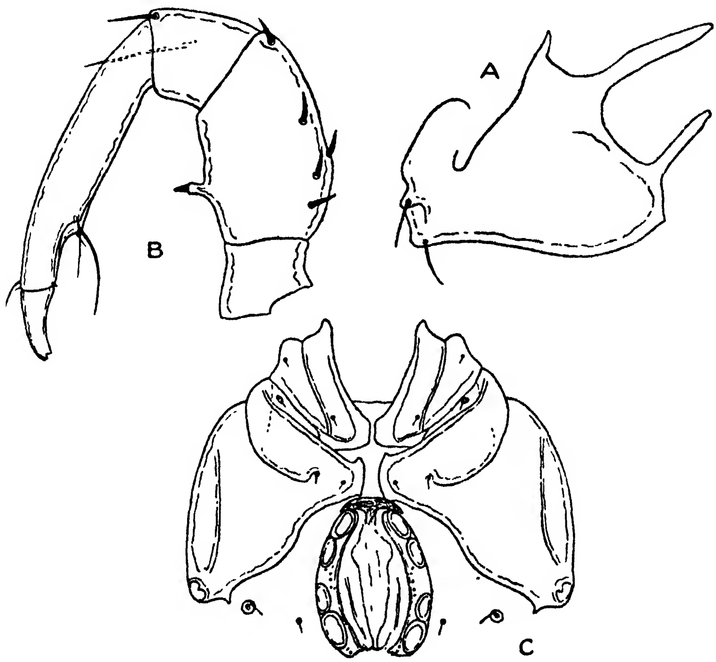
7. PIONA ANGULATA Viets.

Piona angulata Viets, 1921, p. 434; Lundblad, 1927, p. 410.

For details regarding this species, see the above descriptions. The present specimens agree exactly with these.

Locality.—Kenya Colony: Lake Naivasha, from shore-weeds. The species seems to occur in great numbers there, 7 ♂♂ and 76 ♀♀ being found in one of the samples.

TEXT-FIG. 10.



Limnesia aspera Koen. var. *macropora* Viets. ♀.
A. Maxillary organ. B. Palp. C. Epimeral and genital plates.

Subgenus TETRAPIONA Viets.

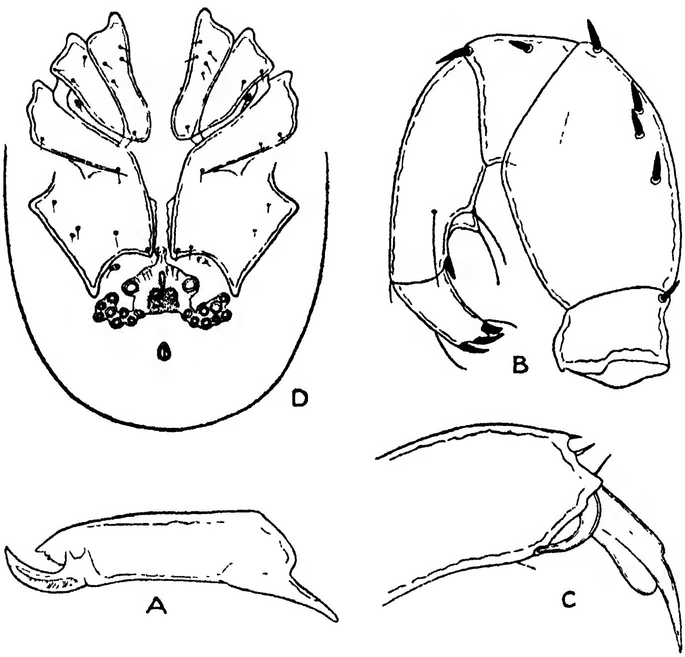
8. PIONA CALIGIFERA (Koen.) var. WORTHINGTONI, var. nov.

Piona caligifera was described by Koenike (1898, p. 410) from Madagascar and later refound in East Africa by Daday (1910 *a*, p. 254). Like *P. forcipata*

(Koen.), from Bagamoyo in the Tanganyika Territory, and *P. longispina* Viets, from the Cameroons, it is a near relative to *P. paucipora* (Thor) and *P. variabilis* C. L. Koch from Europe. In all these five species the male is characterized by having the last two pairs of epimeral plates separated from one another along the median line and by the genital plates not being united with the epimera. The females of these species all possess four genital plates.

The specimens before me differ from Koenike's description of the species in some respects and will be separated as a special variety.

TEXT-FIG. 11.



Piona caligifera (Koen.) var. *worthingtoni*, var. nov. ♂.
A. Mandible. B. Palp. C. Distal end of sperm-transferrer.
D. Epimeral and genital plates.

♂.

Body about 870 μ in length. The palps are short and thick as in *caligifera*. The measurements are (in μ):—

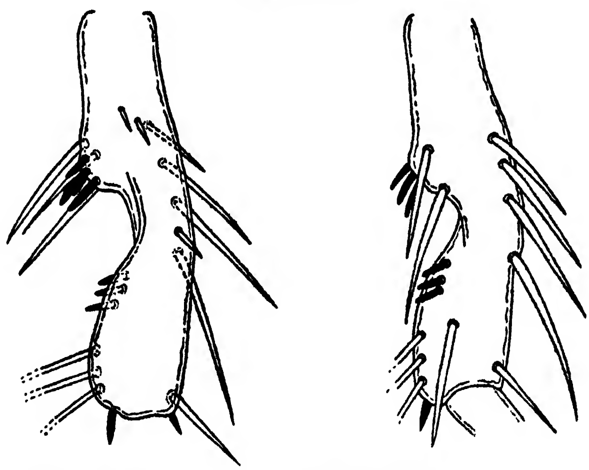
	I.	II.	III.	IV.	V.
Extensor side	39	132	64	125	61
Flexor side...........	32	79	39	82	50

The spines on the 2nd and 3rd segments are very thick and strong. The flexor side of the 4th segment is furnished with two humps, each with one bristle. The humps are arranged side by side, the outer one being larger and situated

a little more distal. The peg inside at the distal end of that segment is rather long, attaining 11 μ in length, and the claws of the last segment are still longer.

The epimera of the 4th pair have a long hinder projection, and behind they are separated 32 μ from each other. The distance between the 4th pair of epimera increases in front, and between those of the 3rd pair it is still greater. The claws of the first two pairs of legs are very large, as is consequently the claw-sheath; that of the second pair, for instance, measures 107 μ out of a length of the last segment of 278 μ. One of the claws of the sperm-transferrer is reduced, semi-circular in shape. The other is greater, but yet rather short. It consists of one pointed main claw in the middle and two lateral, not distinctly separated dilatations, one being better pronounced and more distinctly set apart than the other. The 4th segment of the last leg is long and

TEXT-FIG. 12.



Piona caligifera (Koen.) var. *worthingtoni*, var. nov. ♂.
Clasping segment of 4th leg.

slender with the excavation bordered behind by 3–4 chitinous pegs and 3 swimming hairs. The outer end of the segment has a small pointed spine in each corner, and the side opposite to the excavation bears about 4 long bristles. The number of swimming hairs on the following segment is 3.

The genital plates are very characteristic. They differ from those in *P. caligifera*, *P. forcipata*, *P. longispina*, and *P. variabilis* by being incised in front on each side. In this respect they resemble somewhat those in *P. paucipora*, but in the latter species there are fewer acetabula, the median line of the hinder group of epimera is shorter, the palps are much more slender, as is also the large claw of the sperm-transferrer, which is straighter and possesses a long, curved, accessory hook at the base, shaped in the same way as the smaller claw in *worthingtoni*, and being of about the same size.

In *worthingtoni* there seems always to be an isolated stigma placed in front, which is not the case in *paucipora*, and in some specimens this stigma is considerably larger than the other ones—in other specimens, however, it is of the same size.

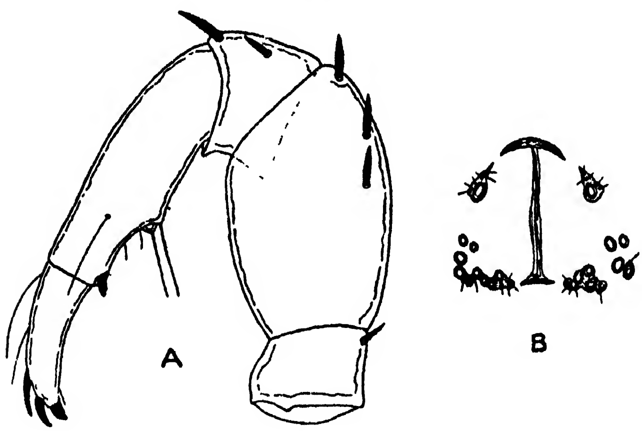
♀.

The female reaches a length of about 1293 μ.

The palps are not as bulky as in the male and the humps are less prominent. The measurements are (in μ) :—

	I.	II.	III.	IV.	V.
Extensor side	36	129	62	132	71
Flexor side...........	29	79	36	98	61

TEXT-FIG. 13.



Piona caligifera (Koen.) var. *worthingtoni*, var. nov. ♀.
A. Palp. B. Genital plates.

The genital organ resembles that of *P. variabilis* or *P. variabilis dispersa* Sokolow, inasmuch as some of the acetabula are lying free in the soft skin. One acetabulum is always widely separated from the others, situated in front of them.

The above variety differs considerably from *caligifera* as described by Koenike in having the male genital plates excavated in front, by possessing swimming hairs on the 4th leg, and two claws on the sperm-transferrer.

Locality.—Kenya Colony: Lake Naivasha, from weedy shore. Rather common.

Type (♂) and allotype (♀) in British Museum

Literature.

Daday, E. von. 1910. Ergebnisse der mit Subvention aus der Erbschaft Treitl unternommenen zoologischen Forschungsreise Dr. Franz Werner's nach dem ägyptischen Sudan und Nord-Uganda.—XV. Beiträge zur Kenntnis der Mikrofauna des Nils. Sitzungsber. d. K. Akad. d. Wiss. in Wien, Math.-naturw. Klasse, cxix, Abt. i. Wien.

——. 1910 *a*. Untersuchungen über die Süsswasser-Mikrofauna Deutsch-Ost-Afrikas. Zoologica, Heft 59. Stuttgart.

Koenike, F. 1893. Die von Herrn Dr. F. Stuhlmann in Ostafrika gesammelten Hydrachniden des Hamburger naturhistorischen Museums. Jahrb. d. Hamburg. Wiss. Anst. x. Hamburg.

——. 1895. Hydrachniden. Deutsch-Ost-Afrika, iv. Berlin.

——. 1898. Hydrachniden. Fauna von Madagaskar und Nossi-Bé. Abhandl. d. Senckenb. naturf. Ges. xxi, Heft. 2, Frankfurt a. M.

——. 1905. Zwei neue Wassermilben aus den Gattungen *Megapus* und *Diplodontus*. Zool. Anzeiger, xxviii. Leipzig.

——. 1906. Hydrachniden aus Java. Jahrb. d. Hamburg. Wiss. Anst. xxiii. Hamburg.

——. 1907. Fünf neue Hydrachniden-Gattungsnamen. Abh. Naturw. Ver. Brem. xix, Heft 1. Bremen.

Lundblad, O. 1927. Zur Kenntnis der Hydracarinenfauna des Mount Elgongebiets im britischen Ostafrika. Archiv f. Hydrobiol. xviii. Stuttgart.

Marshall, Ruth. 1926. Water Mites of the Okoboji Region. Iowa Studies in Nat. Hist. xi.

——. 1929. Canadian Hydracarina. University of Toronto Studies. Publ. of the Ontario Fisheries Research Laboratory, no. 39. Toronto.

Piersig, R. 1901. Hydrachnidae. Das Tierreich, xiii. Berlin.

Viets, K. 1913. Drei neue Wassermilben-Arten aus den Gattungen *Thyas*, *Hydrarachna* und *Arrhenurus*. Abhandl. Nat. Ver. Brem. xxi, Heft 2. Bremen.

——. 1913 *a*. Hydracarinen-Fauna von Kamerun. Archiv f. Hydrobiol. u. Planktonk. ix. Stuttgart.

——. 1914. Hydracarinen aus dem Kaplande. Gesammelt von der Deutschen Südpolar Expedition. Zoolog. Jahrb. Abt. f. Syst. Geogr. u. Biol. xxxvii. Jena.

——. 1916. Ergänzungen zur Hydracarinen-Fauna von Kamerun. Archiv f. Hydrobiol. u. Planktonk. xi. Stuttgart.

——. 1921. Hydracarina. Wiss. Ergebn. d. Deutschen Zentral-Afrika-Expedition, 1907–8, v.

Walter, C. 1924. *Hydrarachna junodi*, un Hydracarien nouveau de l'Afrique Portugaise. Bull. de la Soc. Portugaise d. Sc. Nat. ix. Lisbonne.

——. 1925. Hydracariens de l'Algérie et de la Tunisie. Bull. de la soc. d'Hist. Nat. de l'Afrique du Nord, xvi. Alger.

——. 1927. Acarina I. Hydracarina. Faune des Colonies Françaises.—I. Fasc. 6. Paris (in Monod).

Scientific results of the Cambridge Expedition to the East African Lakes, 1930–1.—9. Leeches.

By J. PERCY MOORE, University of Pennsylvania.
(Communicated by Dr. E. B. WORTHINGTON, F.L.S.)

[Read 8 December 1932]

Family GLOSSIPHONIDAE.

GLOSSIPHONIA CONIFERA, sp. n.

A small species, having the size, form, and general aspect of *G. fusca* Castle. The type measures: length 4·5, to male pore 1·1; widths, at oral ring 0·7, at male pore 1·4, at XIX (maximum) 2·5, at anus 0·8, depths at same points, respectively, 0·3, 0·4, 0·6, and 0·4 mm. Diameter of sucker 0·8 mm. The cotype is slightly shorter, narrower, and deeper, with a sucker of the same size.

Form broad-ovate, strongly depressed, tapering to small head, broadly rounded caudally. Anterior sucker small, but with the lip broadly rounded and closely studded round the margin with goblet-organs. Its cavity rather deep with well-marked rims all round. Mouth a conspicuous pore just anterior to its centre in somite III ventral to the eyes. Eyes 1 pair on the caudal half of the larger anterior annulus of somite III, the pigment-cups extending into the second annulus. They are large, simple, widely separated by about 1½ times their diameter and directed forward and outward.

The gonopores are very obscure, concealed in the deep furrows resulting from the contraction of the annuli at that point. The male appears to be at XII *a1/a2*, the female at XII *a2/a3*, but better-extended specimens or sections will be necessary to determine this. There may be a common orifice. Anus a small pore notching somite XXVII from behind. Caudal sucker a relatively small but sharply defined and muscular circular disk directed ventrad and concealed beneath the body, so that only a narrow crescent and about ¼ of the rim are visible from above.

Sensillae and nephropores cannot be detected in surface-views, but cutaneous papillae are well developed on the dorsum of sensory annuli only. They form five series—median, outer paramedian, and intermediate—separated respectively by six and five longitudinal muscle-bands, with four or five more between the intermediates and the margins of the body, and two in each of the papillae-lines, making forty or forty-two in all. The medians and paramedians begin (sufficiently large to be visible under a × 10 lens) on VIII or IX and continue to XXV. The intermediate series is very incomplete, being represented by small and inconspicuous papillae on only a few somites in the posterior middle body-region. Papillae are distinct low cones containing much black pigment, very prominent in the median and paramedian

series, on which they increase in size antero-caudad until they occupy the full length of the annuli. The series are not strictly linear, as frequently papillae lie to one side or the other of the line, and rarely a papilla will be biconical or divided into two smaller cones lying side by side. In addition to these papillae, the dorsal integument is roughened by numerous Bayer's organs.

Unfortunately, the colour-pattern is lost, the only pigment remaining being confined to the eyes and dorsal papillae.

The annulation is well preserved. I and II are each biannulate, the separating furrow being shallow, and the broadly rounded anterior rim of the lip which they form bears a crowded row of goblet-cells. III biannulate $(a1\ a2) > a3$ with a faint $a1/a2$ furrow. Eyes on the $a2$ component of the larger anterior annulus, but the pigment-cups reaching into $a3$. IV biannulate, with both furrows ($a1/a2$ and $a2/a3$) better developed than on III, but becoming obsolete at the margins where the somite merges with V to form the buccal ring. V triannulate dorsally, biannulate ventrally where $(a1\ a2)$ forms the post-buccal ring, the total length of the annulus being slightly less than IV. VI, the first completely triannulate somite both dorsally and ventrally, $a1 < a2 < a3$. VII–XXIV triannulate; on pregonital somites $a2$ is generally more elevated and projects slightly above the general surface, especially at the margins, while caudal to the gonopores $a3$ is usually longer and faintly biannulate; on XXIV $a3$ is reduced, $a1 = a2 > a3$. XXV biannulate, $(a1 < a2) > a3$. $a1$ being incipient at the margins. XXVI biannulate with no trace of $a1$, and $a3$ very small. XXVII uniannulate and partly including the anus. No papillae are visible on XXVI or XXVII.

Little of the internal anatomy can be made out from the contracted and rather opaque entire specimens cleared in glycerine. The proboscis is relatively short and stout, nearly cylindrical but slightly tapered to the end, which bears a circle of twelve small rounded papillae. On the type it is protruded a distance of 0·8 mm. and has a maximum diameter of 1·6 mm. On the cotype the retracted proboscis reaches from the middle of somite VI to the anterior part of XII. Salivary glands extensively developed, forming a loose cluster extending along each side from somite IX to XVII, their ducts being aggregated into a pair of stout cables which empty into the oesophagus in XIII. Gastric caeca six pairs in XIV to XIX, the first five being small and simple, slightly bulbous and bilobed at the ends, the sixth long, reflexed and reaching to XXV, with a short, rounded, lateral lobe in each somite from XX to XXIV. Intestinal caeca four pairs in XX to XXIII, short and simple. Reproductive organs are concealed largely by the opaque salivary glands.

The cotype bears two egg-capsules containing four and six embryos.

Locality.—Uganda, Lake Bunyoni, among weeds along the shore, station 707 A.

GLOSSIPHONIA WEBERI Blanchard.
Lake Bunyoni, station 716.

GLOSSIPHONIA TRICARINATA Blanchard.
Lake Baringo, Kenya, stations 114 and 115.
Lake Edward, Uganda, station 520.

GLOSSIPHONIA NILOTICA Johansson.
Lake Baringo, Kenya, station 127.

GLOSSIPHONIA STUHLMANNI Blanchard.
Lake Naivasha, Kenya, station 27.

PLACOBDELLA JAEGERSKIOLDI (Johansson).
Lake Edward, Uganda, station 520.
Lake George, Uganda, station 609, from tail of Hippopotamus.

PLACOBDELLA FIMBRIATA (Johansson).
Lake Rudolf, Kenya, station 217, from mouth of Crocodile.

Family HIRUDIDAE.

HIRUDO HILDEBRANDTI Blanchard.
Lake Nabugabo, Uganda.

HIRUDO sp. ?
Lake Naivasha, Kenya, station 27.

LIMNATIS OLIGODONTA Johansson.
Stream running into Lake Hannington, Kenya, station 132.
Lake Bunyoni, Uganda, stations 705 and 707 B.
Lake Nakavali, Uganda, station 812.

Family ERPOBDELLIDAE.

SALIFA PERSPICAX Blanchard.
Lake Baringo, Kenya, station 127.
Lake Edward, Uganda, stations 520, 557 (including some egg-capsules), and 570.

Scientific results of the Cambridge Expedition to the East African Lakes, 1930–1.—10. On some Aquatic Coleopterous Larvae. By Dr. A. D. IMMS, F.R.S., F.L.S.

(With 1 Text-figure)

[Read 8 December 1932]

AMONG a miscellaneous collection of insect larvae obtained by Dr. E. B. Worthington from the Lakes of Kenya and Uganda are some examples belonging to the order Coleoptera. In the absence of bred imagines it has only been possible to indicate the probable specific identity of most of these larvae by comparison with the collections of adult beetles made during the Expedition in the same localities. In this connexion Mr. K. G. Blair of the British Museum (Natural History) has made useful suggestions, as well as with regard to the generic determination of several of the larvae. A series of the specimens has been deposited in the British Museum and duplicates have been placed in the Cambridge University Museum of Zoology.

Family DYTISCIDAE.

Subfamily HYDROPORINAE.

Genus HYPHYDRUS Ill.

One larva 11 mm. long (including rostrum) from papyrus swamp bordering Kazinga channel, Lake Edward (Stn. 516). The species concerned is probably *H. cycloides* Rég., while other members of the genus are known from various parts of Africa.

Genus HYDROVATUS Motsch. ?

One larva, smaller than the foregoing, taken from a swamp at the south end of Lake Baringo (Stn. 114), has a broader rostrum and with the labium quadrangular. It is probably referable to this genus, which is represented by several species of adult beetles from the same locality.

Subfamily DYTISCINAE.

Genus ERETES Cast.

Four adult larvae ranging in length from 17·5 mm. to 18·5 mm. and one young larva, from a closed alkaline pond on west shore of Lake Rudolf (Stn. 240 A).

The genus *Eretes* contains only two species, of which *E. sticticus* (L.) is almost cosmopolitan in the tropics and subtropics (including Africa). The second known species, *E. australis* Er., is Australasian. The larva of *E. sticticus* was first described by Valery Mayet (1887) from Tunis and was subsequently redescribed and figured in detail by Meinert (1901). Meinert's careful and well-illustrated description renders detailed comparison possible with the Lake Rudolf specimens. They exhibit, without exception, all the characters of the larva of *Eretes*, and it may be added that the very short, median, 4-dentate, labial process renders the larvae of this genus easily separable from those of the closely allied Thermonectini (*vide* Bertrand, 1928). Meinert's description and figures are chiefly based upon a larva in the penultimate instar, whereas four of the Lake Rudolf examples are apparently full grown or nearly so. This fact may account for some difference in the relative lengths of the segments of the maxillary and labial palpi as compared with the measurements given by Meinert. For the Lake Rudolf examples the segments of the maxillary palpi are related in length as 3 : 10 : 10 : 7 as compared with 3 : 9 : 9 : 10 given by Meinert ; in the labial palpi the respective figures are 6 : 5 as compared with 12 : 14. That the difference may be due to age, and not to a difference of species, is suggested by the youngest specimen from Lake Rudolf which measures 6·5 mm. in length. In this example the maxillary palpus has its segments related in length as 5 : 15 : 18 : 20 and the labial palpus as 23 : 25, thus agreeing tolerably closely with the proportions given by Meinert. The specimens, therefore, undoubtedly belong to the species *E. sticticus* (L.). Two examples of the adult beetle were also collected during the Expedition from Lake Rudolf.

Genus Cybister Curt.

Three larvae, measuring respectively 21 mm., 51 mm. and 57 mm. in length, among weeds on the east shore of Lake Naivasha (No. 34).

These larvae exhibit all the typical characters of this genus, which is one of almost world-wide range, and are most probably referable to the species *C. tripunctatus* Ol.

Family GYRINIDAE.

Genus Dineutes Macleay.

One larva from a strong stream running into Lake Hannington (Stn. 132). The semicircular head, constricted collum, absence of teeth from the nasale, and the mandibles being devoid of retinacula place this larva in the genus *Dineutes*. It is perhaps referable to the species *D. aereus* (Klug), which was obtained as imagines during the Expedition.

Genus Orectogyrus Régimbart.

One larva from a strong stream running into Lake Hannington, Lake Baringo (Stn. 132). This larva differs from the preceding in the more elongated head,

with the collum not constricted and scarcely differentiated. Its characters show that it is a member of the Orectochilinae and there is little doubt that it is referable to the characteristically African genus *Orectogyrus* Rég. In all probability this larva is that of *O. leroyi* Rég., a species well represented as imagines collected during the Expedition.

Family HYDROPHILIDAE.

Subfamily Spercheinae.

Genus Spercheus Klug.

One larva from among weeds on East shore of Lake Naivasha (Stn. 27).

Two species of the beetles of this genus were collected during the Expedition, but it is not possible to determine whether either is represented by this larva. The larva of the European *S. emarginatus* Schall. is well known, and the example from Lake Naivasha resembles it closely. It is broadly dorso-ventrally flattened: the mandible apically bifid and without molar area: the maxilla with strongly developed spinose lacinia; the palpiger bearing a slender slightly curved galea. The abdominal segments soft and membranous with eight pairs of lateral conical papillae which are probably respiratory in function; the last two abdominal segments are attenuated and not forming a respiratory pocket. Length 2·75 mm.

Subfamily Sphaeridinae.

Genus Coelostoma Brullé.

One larva 9·75 mm. long taken in a hot freshwater spring near the mouth of the Turkwell river, Lake Rudolf (Stn. 291). This larva probably belongs to the species *C. rufitarse* Boh., the beetle of which was also obtained from the same station. Various genera of Hydrophilidae, it may be added, are well known to inhabit hot springs.

Subfamily Hydrophilinae.

Genus Hydrophilus Leach.

One larva 23 mm. long from papyrus swamp bordering the shore of Lake Nakavali (Stn. 812).

The long styliform stipes to the maxilla and the presence of swimming hairs on the femora indicate that this larva belongs to the tribe Hydrophilini, but its genus is uncertain. Its characters show much in common with those of *Hydrophilus* as given by d'Orchymont (1913), to which it probably belongs. The genus is known to occur in Central Africa.

Genus Helochares Muls.

Two larva efrom weedy shore-line of Lake Kijanebalola (Stn. 836), three larvae from among weeds on east shore of Lake Naivasha (Stn. 27), and one larva from swamp at south end of Lake Baringo (Stn. 114) all pertain to this genus or to a nearly related type. The bidentate mandible, asymmetrical 6-dentate clypo-labrum, and characters afforded by the 8th and 9th abdominal segments agree closely with the diagnosis of the genus given by d'Orchymont (1913). Adult beetles of the species *H. consputus* Boh. were collected in some numbers during the Expedition and from all the three localities mentioned. There is little doubt, therefore, that the larvae belong to this same species.

Genus Amphiops Er. ?

Three larvae from weedy shore-line of Lake Kijanebalola (Stn. 836) and one larva from among weeds on east shore of Lake Naivasha (Stn. 27) clearly belong to one and the same genus. These larvae possess the long styliform stipes of the Hydrophilinae, but lack the characteristic swimming-hairs on the femora found in the Hydrophilini. They differ, however, from any described larvae of the group, and it is probable, as Mr. Blair has suggested, that they belong to the genus *Amphiops*.

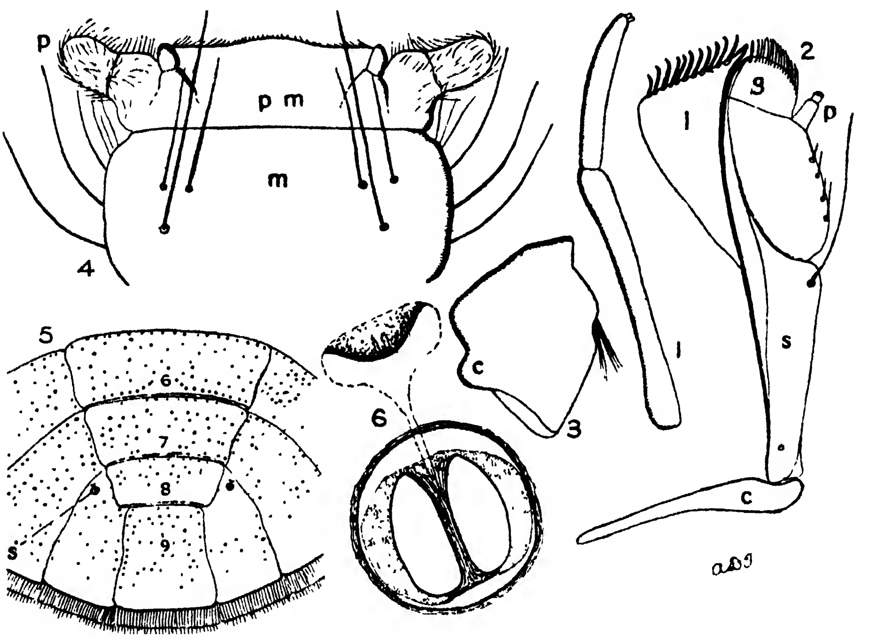
Family DASCILLIDAE.

Genus Eubrianax Kiesw.

Nine examples from 6 mm. to 11 mm. long. From a large river near Nutwanga, Lake Edward, Belgian Congo: 29/6/31. Collected by Mr. L. C. Beadle.

In their very flattened broadly oval limpet-like form, with five pairs of filiform gills attached basally to the 2nd to 6th abdominal segments, these larvae closely resemble those of *Psephenus*. They differ, however, in that the 8th abdominal segment is provided with lateral expansions extending to the margin of the carapace (text-fig., 5). This latter feature they share in common with the oriental genus *Eubrianax*. The larva of *Eubrianax edwardsi* Lec. from North America has been recently described and figured by Böving (1931) and a detailed comparison is thus possible with the specimens collected by Mr. L. C. Beadle. Since Böving's examples did not allow of the mouth-parts in this genus to be figured completely, those of the African specimens are dealt with in some detail. The labrum is broad and well developed with the outer angles rounded; the oral aspect finely hairy and strengthened by two curved cuticular rods extending and converging backwards into the clypeus. The antennae (text-fig., 1), in an example 10 mm. long, measure 1·4 mm. in length: the two segments are related in length as 42 : 23 and the second segment bears two apical papillae. The mandibles (text-fig., 3) of the two sides are alike:

·134 mm. long × ·132 mm. broad, each has a divided penicillum of setae situated about the middle of the inner margin; a molar area is undeveloped. The maxilla (text-fig., 2) has a rod-like single-segmented cardo and well-developed stipes. The stipes is provided with an elongate and very prominent seta near its apex on the outer border; the palpiger is large and bears a short 2-segmented palpus whose second segment carries a double circlet of very minute papillae. The lacinia is apically angulate with its outer distal extremity spine-like and markedly sclerotized; the distal border is armed



1. Antenna, right, ×38. 2. Maxilla, left, ×84: *c*, cardo; *g*, galea; *l*, lacinia; *p*, palpus; *s*, stipes. 3. Mandible, right, ×67: *c*, condyle. 4. Labium, ventral aspect, ×84: *m*, mentum; *p*, palpus; *pm*, prementum. 5. Caudal extremity of larva, 10 mm. long, dorsal aspect, ×9·5: *s*, spiracle; *6–9*, abdominal terga. 6. Spiracle of 8th abdominal segment, left, ×250.

with a row of stout hook-like spines. The galea is rounded distally and projects beyond the palpus; it is fringed with stout closely-set curved spine-like setae. The labium (text-fig., 4) has the prementum transverse and very short, while the palpi are membranous, hairy, and incipiently two-segmented. Close to the base of each palpus, on the ventral aspect, is a two-segmented papilla. The mentum is transverse and about double the length of the prementum.

In discussing the affinities of the larvae of *Eubrianax*, Böving pointed out (1926) that they lie closely with *Psephenus*, but owing to the loss of the maxillary palpi in the specimens examined he was unable to state whether these organs are 4-segmented as in *Psephenus*. In the African examples examined the maxillary palpi are, as previously mentioned, 2-segmented. The African specimens of *Eubrianax* differ also from *Psephenus* in the 2-segmented labial palpi, whereas in the last-mentioned genus these organs are figured by Kellicott (1883) as being 3-segmented.

The African specimens agree so closely with the larva of *Eubrianax* that they can only be related to that genus. The spiracles (text-fig., 6) on the mesothorax and 8th abdominal segment are, however, definitely biforous, whereas, according to Böving, they are 'annuliform' as contrasted with the biforous condition found in related larval types. *Eubrianax* is listed by M. Pic as containing 11 species, of which one occurs in North America and the remainder in Japan and Malaysia. It has, therefore, not so far been recorded from the African continent, but Mr. Blair informs me that there is an undetermined species from Lake Victoria in the collections of the British Museum. The systematic position of this genus is extremely doubtful. While the imagines are usually referred to the Dascillidae, the larva, as pointed out by Böving, is most nearly related to that of *Psephenus*.

Family LAMPYRIDAE.

LUCIOLA sp.

One larva 12·75 mm. long of the *Luciola* type (Stn. 291); from a hot fresh-water spring near the mouth of the Turkwell river, Lake Rudolf.

Above, this larva is dark fuscous-brown with a conspicuous yellow blotch on either side of the prothorax. The integumental areas and ventral surface are cream-coloured. The thoracic and abdominal tergal plates are horny and studded with small cuticular warts. Excepting that of the terminal segment each tergum bears a median dorsal longitudinal carina, becoming less developed posteriorly, and four prominent but short and blunt backwardly directed spines along the hind margin; these spines become more pointed on the hindermost segments. The head bears the usual epicranial sutures, and there are nine pairs of spiracles borne on the epipleura. Fourteen short cylindrical anal appendages of the type prevalent in *Luciola* and related genera are present; four of these are dorsal, three on either side are dorso-lateral, and ventrally there are four of these appendages disposed in two groups. Each appendage bears eight or nine rows of minute hooks.

The larva betrays no special adaptations to an aquatic life. All the spiracles are well developed and apparently functional. The possibility that the larva was crawling on an aquatic plant and got brushed into the water during the collecting cannot be overlooked. On the other hand, it needs to be mentioned

that aquatic larvae of *Luciola* and other Lampyrid genera are known. In the case of the larvae of two species of *Luciola*, described by Okada (1928) from Japan, tracheal gills are present. In other aquatic Lampyrid larvae discussed by Blair (1927) spiracles were either wanting or non-functional or the respiratory system was metapneustic. In the light of these facts, the absence of any modification in the respiratory system of the specimen under consideration suggests that its occurrence in the habitat described may be accidental.

LITERATURE.

BERTRAND, H. 1928. Les Larves et Nymphes des Dytiscides &c. Encycl. Entom. x. Paris.

BLAIR, K. G. 1927. An Aquatic Lampyrid Larva from S. Celebes. Trans. Ent. Soc. London, pp. 43–45, 1 fig.

BOVING, A. G. 1926. The Immature Stages of *Psephenoides gahani* Champ. Trans. Ent. Soc. London, p. 385.

——. 1931. An Illustrated Synopsis of the principal Larval Forms of the Order Coleoptera. Brooklyn, N.Y.

D'ORCHYMONT, A. 1913. Contribution à l'étude des Larves Hydrophilides. Ann. Biol. Lacus, vi, pp. 173–214.

KELLICOTT, D. S. 1883. *Psephenus lecontei*—on the External Anatomy of the Larva. Canad. Ent. xv, p. 195, fig. xi.

MAYET, V. 1887. Ann. Soc. Ent. Fr. Bull. xiv, p. ccii.

MEINERT, F. 1901. Vandkalvelarverne (Larvae Dytiscidarum). D. Kgl. Danske Vidensk. Selsk. Skrifter 6 Raekke, naturvidensk. og. Math. Afd. ix, 8, pp. 341–440.

OKADA, Yô K. 1928. Two Japanese Aquatic Glow-worms. Trans. Ent. Soc. London, pp. 101–108, pl. viii, and 6 text-figs.

Scientific Results of the Cambridge Expedition to the East African Lakes, 1930–1.—11. The Cichlid Fishes. By ETHELWYNN TREWAVAS, B.Sc. (Communicated by Dr. E. B. WORTHINGTON, F.L.S.)

(With 6 Text-figures)

[Read 2 February 1933]

CONTENTS.

	Page
I. Introduction	309
II. List of species of Cichlidae recorded from the lakes explored by the Expedition	312
III. Notes on the measurements employed	313
IV. *Tilapia*	313
V. *Pelmatochromis*	320
VI. *Astatoreochromis*	321
VII. *Haplochromis*	321
H. rudolfianus	321
Species of *Haplochromis* from Lake Nabugabo	322
Species of *Haplochromis* from Lakes Edward (and George), Nakavali, Kachira, and Kijanebalola.	
Synopsis	326
Descriptions	327
VIII. *Schubotzia*	340
References	340

I. INTRODUCTION.

The Cichlidae of the African lakes present many problems of great interest to the zoologist, and I am very glad to have had the opportunity of working on Dr. Worthington's collection—the more so as Dr. Tate Regan's advice and constant interest have greatly facilitated my task.

Of the two Great Lakes surveyed by the Cambridge Expedition, Lake Rudolf has a poor Cichlid fauna, Lake Edward a very rich one. This may have some relation, as Dr. Worthington suggests, to the abundance in Lake Rudolf of large predacious fishes of other families, and to their absence from Lake Edward. In this respect Lake Rudolf is like Lake Albert, and Lake Edward resembles the Victoria Nyanza.

The most surprising member of the Lake Rudolf fauna is a new species of *Pelmatochromis*. Until now, this genus was known only from the Congo

and West Africa (Regan, 1922 (*b*), p. 252). The Lake Rudolf species does not stand away from the rest of the genus in structure, but appears to be very closely related to *P. kribensis* and *P. caudifasciatus* of South Cameroon. The rivers of Southern Cameroon are usually considered as being related to the Congo basin rather than the Niger–Chad–Nile system (see Boulenger, 1905, p. 16), but Lake Rudolf was once part of the Nile system, and its fauna is typically Nilotic in character. In any case, it is very difficult to suggest why a genus unknown in Lake Chad and the Nile should be represented in Lake Rudolf by so typical a species.

Lake Rudolf has three common Nile species of *Tilapia*, one of which, *T. zillii*, has been previously recorded from the lake, and one small endemic *Haplochromis*, here described for the first time. In addition, one of the crater-lakes of Central Island has its own form of *Tilapia*, which has clearly evolved from a colony of *T. nilotica* that has become isolated; it is here given specific rank.

In 1914 Boulenger described an endemic genus, *Schubotzia*, and three endemic species of *Haplochromis* from Lake Edward. The collection was a German one (Schubotz), and the types are in Berlin, but there are duplicates in the British Museum (Natural History). Boulenger also assigned a number of specimens to Lake Victoria species. Regan (1921) considered that all the British Museum material of *Haplochromis* from Lake Edward belonged either to Boulenger's endemic species, or to three new endemic species which he then established. Later (1925), Regan described three further species of the Lake Edward fauna. Dr. Worthington's collection from this lake includes representatives of five of the nine previously known endemic *Haplochromis*, six new endemic *Haplochromis* and a new *Tilapia*, a good sample of *T. nilotica*, and specimens of five species previously known from Lake Victoria. Only one of these last (*Haplochromis macrops*) was also recorded from the lake by Boulenger, and that from only two specimens, not seen by Regan. It is therefore assumed in this paper, as it was by Regan in 1921, that Boulenger's identifications of Lake Edward fishes as *H. martini*, *H. serranus*, and *H. spekii*, of Lake Victoria, and also as *H. graueri* of Lake Kivu, are erroneous.

The similarity of the Lake Edward Cichlid fauna to that of Lake Victoria is, nevertheless, striking. *Tilapia nilotica* is the only species it possesses in common with Lake Albert and the White Nile, unless *Haplochromis multicolor*, which was taken in the Semliki River and not in the lake itself, be included. None of the five species (including *Astatoreochromis alluaudi*), regarded as identical with Lake Victoria forms, is known below the Murchison Falls on the one hand and the Semliki Falls on the other. Its endemic *Tilapia* is closely allied to *T. variabilis* and *T. esculenta* of Lakes Victoria and Kioga, and the relationships of its sixteen endemic species of *Haplochromis* are very obviously with the Lake Victoria members of this genus.

The small swampy lakes between Lakes Edward and Victoria, namely

Kachira, Kijanebalola, and Nakavali, were looked to with interest as being on a possible route by which an interchange between the faunas of the two great lakes might have taken place. They yielded three Cichlid species, *Haplochromis nubilus*, *H. multicolor*, and *Astatoreochromis alluaudi*. The first and last of these are among the commonest species of both Great Lakes. *Haplochromis multicolor* is not common in collections from Lake Victoria and was not taken in Lake Edward, although three specimens were brought from the Semliki River above the rapids. This little fish appears to be the only Nile Cichlid present in the Victoria–Kioga lake system above the Murchison Falls, and its apparent absence from Lake Edward still leaves doubt as to the route by which it came.

If these three lakes are indeed on the route by which Lake Edward has received its Cichlidae, or their not very remote ancestors, from Lake Victoria, we have still no evidence of the passage through them of such specialized types as *Haplochromis ishmaeli* (with massive pharyngeal teeth suited for grinding mollusc shells), the mobile-lipped *H. labiatus*, closely related to *H crassilabris* of Lake Victoria, and the form with serried rasping teeth represented by *H. serridens* of Lake Edward and *H. nigrescens* and *H. nuchisquamulatus* of Lake Victoria. It may be that the conditions in the small swampy lakes were not suitable to their colonization by these species: but we cannot yet assume that collections are sufficiently exhaustive to have included samples of the rarer fishes if they were present.

Evidently, since the time of major intercommunication between the two Great Lakes, the ancestor of the Lake Edward *Tilapia leucosticta* has become divided in Lake Victoria into the inshore-dwelling *T. variabilis* and the deeper-water form, *T. esculenta*, and the ancestor of *Haplochromis serridens* has split into two species in Lake Victoria. In the same way *Haplochromis cinereus* of Lake Victoria seems to be represented by several related species in Lake Edward.

The Cichlidae of Lake Nabugabo give an outstanding demonstration of the rapidity of the effect of isolation. The lake is stated to be separated from Lake Victoria by a sand-spit of geologically recent formation, but of the five species here recorded from it, three are endemic, although their relationships with Victoria species are obvious. *Haplochromis annectidens*, for instance, of Lake Nabugabo, represents the stock from which *H. obliquidens* and *H. plagiodon* of Lake Victoria appear to have diverged in separate directions. *H. beadlei* of Lake Nabugabo, and *H. sauvagei* and *crassilabris* of Lake Victoria, have evolved from a common stock, the stock that also produced *H. labiatus* of Lake Edward, the more extreme *H. chilotes* of Lake Victoria, and apparently also *H. paucidens* of Lake Kivu.

In this paper fifteen new species are described, all except one from the collections of the Cambridge Expedition.

II. List of species of Cichlidae recorded from Lakes Naivasha, Baringo, Rudolf, Nabugabo, Kijanebalola, Kachira, Nakavali, Edward (and George), and Bunyoni.

	Known range of distribution.
LAKE NAIVASHA.	
Tilapia nigra (Günther) (introduced, 1925).	Athi River System, British East Africa.
LAKE BARINGO.	
Tilapia nilotica (Linn.)	Palestine; Nile System; Lakes Rudolf, Albert, Edward, Kivu, Tanganyika, Mweru; Ankole; Abyssinia; Kenya; Tanganyika Territory; Lake Chad; Senegal; Niger.
LAKE RUDOLF.	
Tilapia zillii (Gervais)	Palestine; Nile system to Lake Albert and Victoria Nile below Murchison Falls; Upper Niger.
Tilapia nilotica (Linn.)	(See above under Lake Baringo.)
Tilapia galilaea (Artedi)	Palestine; Nile, to Lake Albert; Senegal; Niger.
Pelmatochromis exsul, sp. n.	Endemic.
Haplochromis rudolfianus, sp. n.	Endemic.
CRATER LAKE A OF CENTRAL ISLAND, LAKE RUDOLF.	
Tilapia vulcani, sp. n.	Endemic.
LAKE NABUGABO.	
Tilapia esculenta Graham	Lake Victoria.
Haplochromis pellegrini Regan	Lakes Victoria and Kioga.
Haplochromis velifer, sp. n.	Endemic.
Haplochromis annectidens, sp. n.	Endemic.
Haplochromis beadlei, sp. n.	Endemic.
LAKE KIJANEBALOLA.	
Haplochromis multicolor (Hilgendorf) ...	Lower Nile, White Nile, Bahr-el-Jebel, Lake Albert; Semliki River; Lake Victoria.
Haplochromis nubilus (Boulenger)	Victoria Nile above Murchison Falls, Lake Kioga, Lake Victoria; Lake Edward; Semliki River.
LAKE KACHIRA.	
Haplochromis nubilus (Boulenger)	(See above, under Lake Kijanebalola.)
Astatoreochromis alluaudi Pellegrin	Lake Victoria; Victoria Nile; Lake Edward.
LAKE NAKAVALI.	
Haplochromis nubilus (Boulenger)	(See under Lake Kijanebalola.)
Astatoreochromis alluaudi Pellegrin......	(See under Lake Kachira.)
SEMLIKI RIVER (above the rapids).	
Haplochromis multicolor (Hilgendorf)	(See under Lake Kijanebalola.)
Haplochromis nubilus (Boulenger)	(See under Lake Kijanebalola.)

List of Species of Cichlidae (continued).

	Known range of distribution.
LAKES EDWARD AND GEORGE.	
Tilapia nilotica (Linn.)	(See under Lake Baringo.)
Tilapia leucosticta, sp. n.	Endemic.
Haplochromis nubilus (Boulenger)	Victoria Nile; Lakes Kioga, Victoria, Kijanebalola, Kachira, Nakavali; Semliki River.
Haplochromis guiarti (Pellegrin)	Lakes Kioga and Victoria.
Haplochromis ishmaeli Boulenger	Lake Victoria.
Haplochromis macrops (Boulenger)	Lake Victoria.
Haplochromis schubotzi Boulenger	Endemic.
Haplochromis angustifrons Boulenger	Endemic.
Haplochromis pappenheimi (Boulenger) ..	Endemic.
Haplochromis eduardii Regan	Endemic.
Haplochromis nigripinnis Regan	Endemic.
Haplochromis mentatus Regan	Endemic.
Haplochromis squamipinnis Regan	Endemic.
Haplochromis fuscus Regan	Endemic.
Haplochromis serridens Regan	Endemic.
Haplochromis limax, sp. n.	Endemic.
Haplochromis engystoma, sp. n.	Endemic.
Haplochromis vicarius, sp. n.	Endemic.
Haplochromis elegans, sp. n.	Endemic.
Haplochromis labiatus, sp. n.	Endemic.
Haplochromis taurinus, sp. n.	Endemic.
Haplochromis dolorosus, sp. n	Endemic.
Schubotzia eduardiana Boulenger	Endemic.
Astatoreochromis alluaudi Pellegrin	Victoria Nile, Victoria Nyanza, Lakes Kachira and Nakavali.
LAKE BUNYONI.	
Tilapia inducta, sp. n.	Probably introduced from rivers flowing into Lake Edward.

III. NOTES ON THE MEASUREMENTS EMPLOYED.

'Total length' includes the caudal fin.

In measurements of proportions 'the length' is the standard length—that is, to base of caudal.

'Length of snout' is measured from the anterior edge of the eye to the *level* of the end of the snout, along a line parallel to the longitudinal axis of the fish.

IV. TILAPIA A. Smith, 1840.

TILAPIA NILOTICA (Linn.).

Boulenger, 1915, p. 162, fig. 106.

Tilapia nilotica is represented in the collections of the Cambridge Expedition by samples from Lake Rudolf, Crater Lake C of Central Island, Lake Rudolf, Lake Baringo, Lakes Edward and George. These are all distinguished from

the related species (*T. galilaea*, *T. variabilis*, and *T. esculenta*) by a combination of the following characters :—depth of body 2 to 2½ in the length ; diameter of eye 3¾ to 5 in length of head in adults (135 mm. and over) ; depth of praeorbital 4½ to 6⅔ in length of head ; teeth in 3 to 8 series, the outer mainly bicuspid, or some tricuspid, up to 90 in outer series of upper jaw ; 9 or 10, occasionally 11, soft rays in the anal fin ; caudal peduncle deeper than long.

The samples from Lake Edward and Lake Rudolf are fairly typical of the species, but the Lake Baringo form has a narrower range of variation in certain characters. Notes follow on each of these colonies.

Lakes Edward and George.

Eleven specimens, 78 to 320 mm. in total length, from stations 501, 514, 517, 570, and from Lake George. Eight of these are over 130 mm. in total length.

Depth of body 2 to 2⅓ in the length (adults). Diameter of eye 3¾ to 4¾ (3¼ to 3⅗ in young) in length of head, depth of praeorbital 4⅗ to 6 (adults). Teeth in 3 to 7 series, usually 4 or 5, the outer bicuspid, or (in a large male) a few tricuspid ; 60 to 90 in outer series of upper jaw. 20 to 25 gill-rakers on lower part of anterior arch. 31 or 32 scales in a longitudinal series, 4 to 5, usually 4½, from origin of dorsal to lateral line, 5 to 7 between pectoral and pelvic fins, 19 or 20, usually 20 round middle of caudal peduncle. Dorsal XVI (3 specimens) or XVII (8 specimens) 12–14 (12 in seven, 13 in three, 14 in one). Anal III 9–11 (9 in four, 10 in six, 11 in one).

Lake Baringo.

Twenty specimens, 62 to 305 mm. in total length, from stations 102, 106, 112, 116, and 126. Ten of these are over 130 mm. in total length.

Depth of body, in adults, 2⅕ to 2½ in the length. Diameter of eye 3¾ to 5 in length of head, depth of praeorbital 5 to 5½ (both measurements in adults only). Teeth in 3 to 5 series, 46 to 70 in outer series of upper jaw (adults) ; inner tricuspid, outer bicuspid in younger, tricuspid in older fishes, except in the one large male (272 mm.), in which they have become simple by the wearing down of the crowns. 31 to 33 scales in a longitudinal series, 4 to 5 from origin of dorsal to lateral line, 7 to 9 between pectoral and pelvic fins (6 in a few young), 19 or 20, usually 19, round middle of caudal peduncle. Dorsal XVI 12–13 (12 in three, 13 in seventeen). Anal III 9–11 (9 in six, 10 in thirteen, 11 in one).

Lake Rudolf.

Eighteen specimens, 64 to 320 mm. in total length, from stations 207, 212, 244, and 285. Ten are over 130 mm. long.

Depth of body 2 to 2⅔ in the length. Diameter of eye 4 to 4¾ in length of head in adults, 3½ in young, depth of praeorbital 5 to 6¼. Teeth in 3 to 8 series, 5 or less in specimens of less than 180 mm., the outer bicuspid ; 40 to 90 in outer series of upper jaw. 22 to 28 gill-rakers on lower part of anterior arch. Scales 4½ or 5 between origin of dorsal and lateral line, 6 to 8

between bases of pectoral and pelvic fins, 19 to 22 round middle of caudal peduncle. Dorsal XVI or XVII (in equal numbers) 13–15, usually 13 or 14 ; last spine $\frac{1}{2}$ length of head or less, rarely a little more. Anal III 10–11, usually 10 ; last spine from a little shorter to a little longer than last dorsal, the relatively longest (in a 118 mm. specimen) contained $1\frac{4}{5}$ times in the length of the head.

Crater Lake C of Central Island, Lake Rudolf.

Eight specimens, 100 to 150 mm. in total length.

Depth of body $2\frac{1}{4}$ to $2\frac{1}{2}$ in the length. Diameter of eye $3\frac{1}{4}$ to 4, depth of praeorbital $5\frac{2}{3}$ to $6\frac{2}{3}$. Teeth in 3 to 4 series, the outer bicuspid ; 54 to 68 in outer series of upper jaw. 19 to 21 gill-rakers on lower part of anterior arch. Scales between origin of dorsal and lateral line 5, between bases of pectoral and pelvic fins 7 or 8 Dorsal XV–XVI (XV in one specimen), 13 to 15 ; last spine from a little less to a little more than $\frac{1}{2}$ length of head, the longest contained $1\frac{5}{6}$ times in length of head. Anal III 10 : last spine about equal in length to last dorsal.

A separate description of these specimens has been given to show that, unlike the *Tilapia* of Crater Lake A, they cannot be separated from *T. nilotica*. It would seem that the fishes are affected less by the alkalinity of the water, which is very high in Crater Lake C (see Beadle, 1932, pp. 190–192), than by the quantity of algal food-material present, in which Lake A is poorer than Lake C. Moreover, Crater Lake C is separated from the main lake by a wall only 5 feet high, Crater Lake A by a 20-foot wall. so that the stock in Lake C is probably not infrequently reinforced from the main lake.

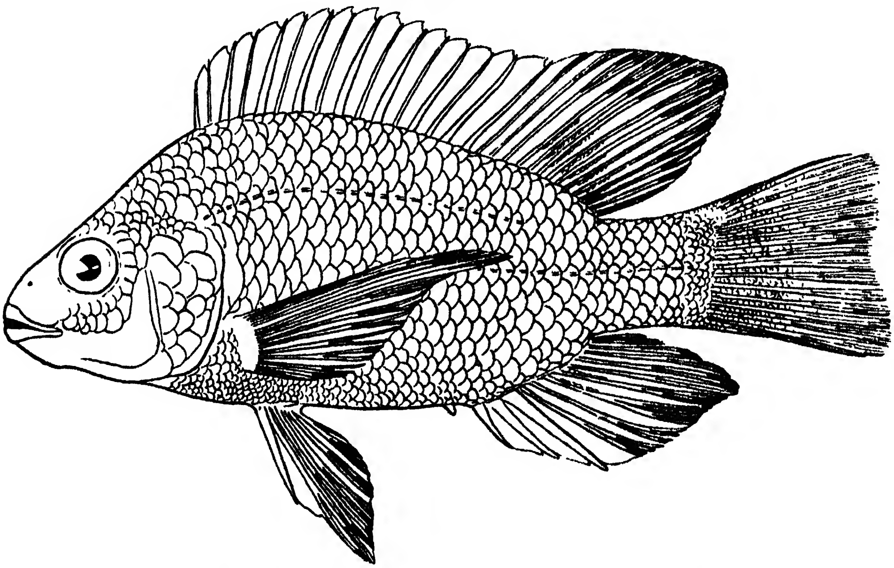
TILAPIA VULCANI, sp. n.

Depth of body $2\frac{1}{3}$ to $2\frac{2}{3}$ in the length, length of head 3. Length of snout $3\frac{2}{3}$ to 4 in length of head, diameter of eye $3\frac{1}{2}$ to 4, depth of praeorbital $4\frac{2}{3}$ to 6, interorbital width 2 to $2\frac{1}{2}$. Maxillary extending to below anterior edge of eye. Teeth in 6 to 8 series, inner tricuspid, outer bicuspid in younger fish (153 mm.), with the lateral and some anterior teeth tricuspid in older fish : 70 to 100 in outer series of upper jaw ; all teeth with slender shafts. 20 to 25 gill-rakers on lower part of anterior arch. 2 series of scales on the cheek, or a single additional scale. Lower pharyngeal as in *T. nilotica* (text-fig. 3, A). 31 to 33 scales in a longitudinal series. $4\frac{1}{2}$ or 5 between origin of dorsal and lateral line, 6 to 9 between bases of pectoral and pelvic fins, 18 to 21 round middle of caudal peduncle. Dorsal XV–XVI (usually XVI) 14–16. Anal III 10–11, usually 10 ; third spine $\frac{1}{2}$ length of head or a little more. about as long as last dorsal. Pectoral reaching origin of anal fin or beyond. Caudal truncate. Caudal peduncle as long as deep, or nearly.

Described from seven specimens, 153 to 308 mm. in total length, from Crater Lake A of Central Island, Lake Rudolf. Six of these are large, deeply coloured males, with very dark vertical and pelvic fins.

Eight young fishes, 75 to 120 mm. in total length, from the same locality, also belong to this species. A brief description of them follows for comparison with young *T. nilotica*. Depth of body $2\frac{2}{5}$ to $2\frac{2}{3}$ in the length, length of head $2\frac{3}{5}$ to 3. Diameter of eye about $\frac{1}{3}$ length of head. Maxillary reaching vertical from anterior edge of eye or nearly. Teeth in 5 to 7 series in all except the smallest, in which there are 3; outer bicuspid, inner tricuspid; 42 to 72 in outer series of upper jaw. 19 to 21 gill-rakers on lower part of anterior arch. Dorsal XVI 13–15. Anal III 10–11; third spine from a little more than $\frac{1}{2}$ to $\frac{3}{5}$ length of head, a little longer than last dorsal. Caudal truncate or subtruncate. Caudal peduncle $\frac{3}{4}$ to as long as deep. About eight vertical stripes on the body, accentuated along the middle of the side. Soft dorsal and caudal with narrow vertical stripes.

TEXT-FIG. 1.



Tilapia vulcani, from a specimen 297 mm. in total length.

Tilapia vulcani is evidently closely related to *T. nilotica*, of which it may be an aberrant colony, the distinctive characters of which are the result of the peculiar environmental conditions of a crater lake. The large males are extremely lean, and this is evident not only in the width of the body but in its depth, especially behind the middle, including the caudal peduncle. Specimens of all ages from this lake are easily recognisable by the relatively larger head and eye and by the long dorsal spines; in addition, the teeth form broader bands, especially in the young. The Tilapias from Crater Lake C, on the other hand, have the appearance of typical *T. nilotica*, and resemble *T. vulcani* only in that the number of dorsal spines does not

exceed XVI (*cf.* also the Lake Baringo colony of *T. nilotica*). It has therefore been thought best to describe *T. vulcani* as a new species, although eventually it may have to be considered a subspecies of *T. nilotica.*

T. eduardiana, from the S.E. slopes of Mount Ruwenzori, forms an interesting parallel to *T. vulcani* in the high spinous fins and long caudal peduncle, but in it the teeth in the jaws are small, in only 3 series, and the pharyngeal teeth, although remaining as large as in *T. nilotica*, are restricted to the posterior part of the triangular plate.

TILAPIA NIGRA (Günther).

Boulenger, 1915, p. 152, fig. 99.

Twenty-seven specimens, 87 to 360 mm. in total length from Lake Naivasha, into which they were introduced in 1925.

TILAPIA GALILAEA (Artedi).

Boulenger, 1915, p. 169, fig. 109.

Six specimens, 130 to 337 mm. in total length, from Lake Rudolf (stations 244, 253, 285, and 298).

TILAPIA ESCULENTA Graham.

Graham, 1928, p. 209, pls. ix–xi.

A single specimen, 255 mm. in total length, from Lake Nabugabo (station 837).

TILAPIA INDUCTA, sp. n.

Depth of body $2\frac{2}{5}$ in the length, length of head $3\frac{1}{3}$. Snout 3 in length of head, diameter of eye $5\frac{1}{2}$, depth of praeorbital $4\frac{2}{3}$, interorbital width $2\frac{1}{4}$, length of lower jaw 3. Jaws equal anteriorly : maxillary ending between nostril and eye. Teeth in six series, outer bicuspid, inner tricuspid, 80 in outer series of upper jaw. Two series of scales on the cheek. 23 gill-rakers on lower part of anterior arch. Lower pharyngeal with moderately small teeth, covering a dentigerous area whose median axis is at least as long as the anterior blade of the bone. 31 scales in a longitudinal series, $3\frac{1}{2}$ from origin of dorsal to lateral line, 5 or 6 between pectoral and pelvic fins, 16 round the middle of the caudal peduncle. Dorsal XVII 12 ; last spine $2\frac{2}{5}$ in length of head. Anal III 9 ; third spine a little longer than last dorsal. Pectoral $1\frac{1}{5}$ as long as head, extending to above vent. Caudal truncate. Caudal peduncle deeper than long. Colour dark brownish grey above, a brown spot on the middle of each scale on the flanks, paler, but still tinged with grey below ; pelvics dark, except near the inner edge ; caudal and posterior half of dorsal spotted ; soft anal dark at the base.

A single specimen, a female 300 mm. in total length, from Lake Bunyoni.

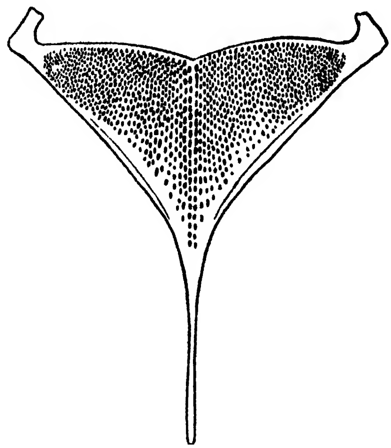
So far as is known there were no Cichlids in Lake Bunyoni until 1924, when two attempts were made to introduce into it a *Tilapia* *. Young Tilapias

* For this information I am indebted to Dr. Worthington.

were taken from the Ishasha and Ntungwe Rivers, which flow into Lake Edward from the East, and were cultivated in fish-ponds fenced off from Lake Bunyoni. Some of these were set free in the Lake, but the experiment does not seem to have been successful, and this single specimen was the whole reward of several nights of fishing.

Tilapia inducta agrees with *T. variabilis* in almost every feature, except the pharyngeal dentition, which is a little stronger than that of *T. nilotica*.

TEXT-FIG. 2.

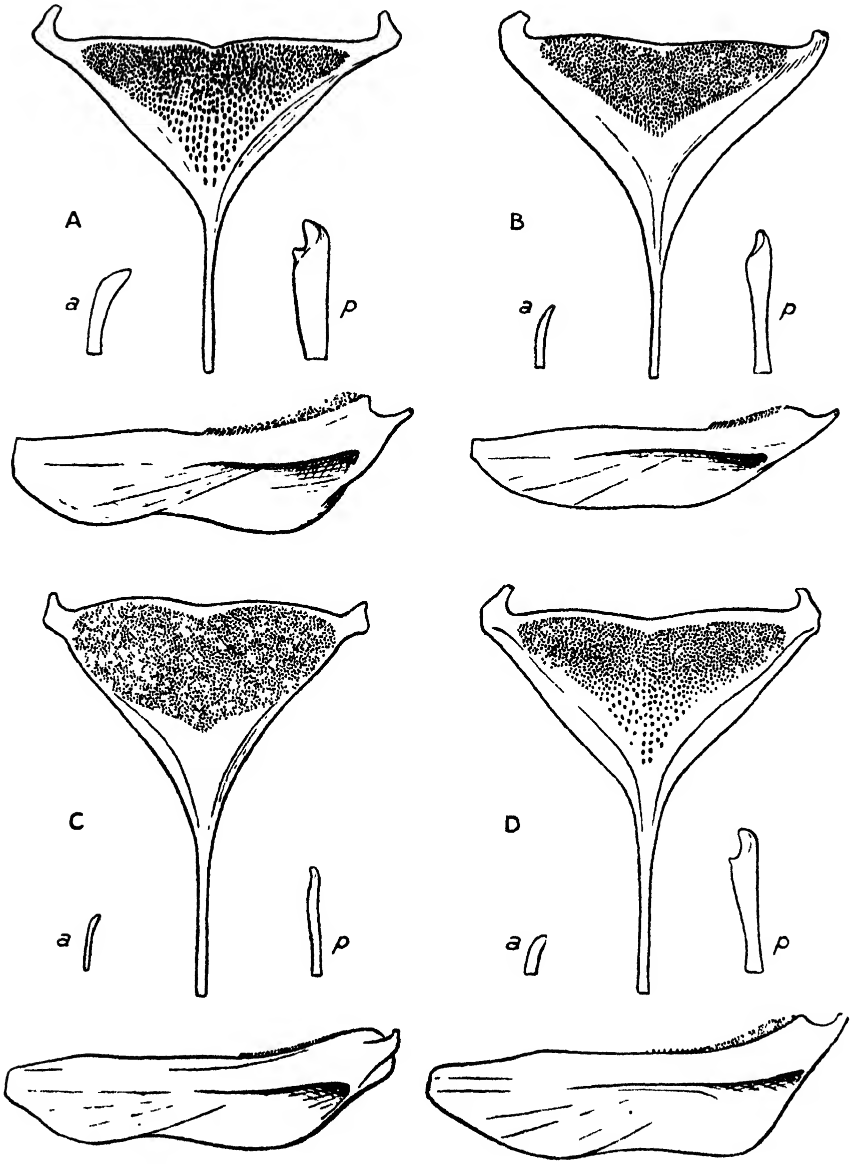


Tilapia inducta. Lower pharyngeal bone of the type. ×2.

TILAPIA LEUCOSTICTA, sp. n.

Depth of body $2\frac{2}{5}$ to $2\frac{3}{5}$ in the length, length of head about 3. Length of snout $3\frac{1}{5}$ to $3\frac{1}{2}$ in length of head, diameter of eye 4 to $4\frac{1}{2}$, depth of praeorbital $4\frac{3}{4}$ to $5\frac{1}{2}$, interorbital width $2\frac{1}{4}$ to $2\frac{1}{2}$. Jaws equal anteriorly, or lower jaw slightly projecting; maxillary ending below nostril or a little behind it. Teeth small, in 3 to 5 series, the outer bicuspid, the inner tricuspid; 70 to 100 in outer series of upper jaw. 2 series of scales on the cheek. 19 to 22 gill-rakers on lower part of anterior arch. Lower pharyngeal with fairly long anterior blade and with numerous minute teeth; dentigerous area restricted to posterior part of the triangular plate (text-fig. 3, B). Scales 30 or 31 in a longitudinal series, 3 or 4 between origin of dorsal and lateral line, 3 to 5 between bases of pectoral and pelvic fins, 16 to 18 round middle of caudal peduncle. Dorsal XVI–XVII 11–12; last spine $2\frac{1}{4}$ to $2\frac{1}{3}$ in length of head. Anal III–IV 9–11; last spine about as long as last dorsal. Pectoral extending to above origin of anal or beyond. Caudal truncate. Caudal peduncle $\frac{3}{4}$ to $\frac{4}{5}$ as long as deep. Upper part of head and nape dark; on rest of body each scale in part dark, in part pearly grey; dorsal, soft anal, and caudal spotted.

TEXT-FIG. 3.



Lower pharyngeal bones in four species of *Tilapia*, seen in dorsal and lateral views, × 2. A. *T. nilotica*, from a Lake Edward specimen of 280 mm. B. *T. leucosticta*, from a fish of 257 mm. C. *T. galilaea*, from a specimen of 245 mm. from the Fayum. D. *T. variabilis*, a 265 mm. specimen from Victoria Nyanza: *a*. an anterior, *p*. a posterior tooth, × 10.

Lake George, Kazinga Channel, and Lake Edward.

Described from three specimens, 163 to 278 mm. in total length, from stations 618 and 504.

Five young fish, 78 to 102 mm. long, also belong to this species. They agree with the adults except in juvenile characters; one of them has 13 soft rays in the dorsal fin; the scales round the caudal peduncle number 15 or 16; there are 9 dark vertical stripes on the body.

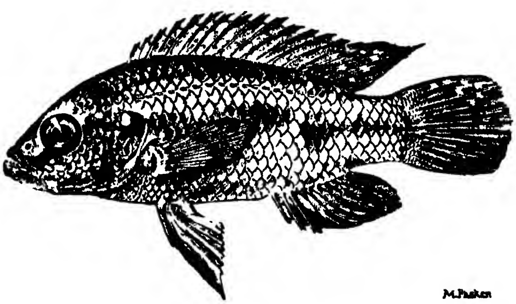
This species is easily distinguished from *T. nilotica* by its larger scales and its pharyngeal dentition. Its nearest relationship is with *T. variabilis* and *T. esculenta* of Lake Victoria. It resembles the one of these in size and number of scales, gill-rakers and fin-rays, the other in depth of praeorbital and in the dentition. It differs from both in having a more slender form and shorter caudal peduncle. Of the three species *T. variabilis* has the dentigerous area of the lower pharyngeal least restricted, *T. leucosticta* most restricted.

TILAPIA ZILLII (Gervais).

Boulenger, 1915, p. 197, fig. 126.

Four specimens, 120 to 197 mm. in total length, from Lake Rudolf (stations 285 and 288).

TEXT-FIG. 4.



Pelmatochromis exsul, 44 mm. specimen (holotype).

V. PELMATOCHROMIS Steind., 1894.

Regan, 1922 (*b*), p. 252.

PELMATOCHROMIS EXSUL, sp. n. (Text-fig. 4.)

Depth of body $2\frac{3}{4}$ to 3 in the length, length of head $2\frac{3}{4}$. Upper profile of snout straight. Snout 4 to $4\frac{2}{3}$ in length of head, diameter of eye $3\frac{1}{3}$ to $3\frac{1}{2}$, depth of praeorbital 7 to 8, interorbital width 4 to $4\frac{1}{3}$. Mouth with somewhat oblique cleft; jaws equal in front, or lower slightly projecting, lower $2\frac{2}{5}$ to $2\frac{3}{5}$ in length of head; maxillary ending below anterior edge of eye. Teeth in a single series, or a few inner teeth in upper jaw; 20 to 32 in outer series of upper jaw. 4 series of scales on the cheek. 5 to 7 gill-rakers on lower part of anterior arch. Lower pharyngeal with teeth bicuspid, few (6 in

a middle series), the middle somewhat enlarged. 26 or 27 scales in a longitudinal series, 4 from origin of dorsal to lateral line, 4 or 5 between pectoral and pelvic fins. Dorsal XIV–XV 10–11 ; last spine $\frac{2}{5}$ to nearly $\frac{1}{2}$ length of head. Anal III–IV 8–9 ; last spine $2\frac{1}{2}$ to $2\frac{2}{3}$ in length of head. Pectoral $\frac{2}{3}$ to $\frac{3}{4}$ length of head, ending above vent or in front of it. Caudal rounded. Length of caudal peduncle $\frac{2}{3}$ to $\frac{3}{4}$ its depth. Silvery, with a dark band along the back, another on lower lateral line, and an indefinite patch below upper lateral line ; an opercular spot, and a faint bar below eye ; a few light spots on upper part of caudal and on soft dorsal ; vertical fins with dark edges ; outer parts of pelvics dusky. The two smaller fishes are much darker in general colouring, and in them the dorsal fin has a clear edge.

Lake Rudolf.

Three specimens, 32 to 44 mm. in total length, from stations 264 and 285. The pale specimen is from the East shore, the two dark specimens are from the shore of Central Island, where the sand is black.

This species appears to be most nearly related to *P. kribensis* and *P. caudifasciatus* from Southern Cameroon.

VI. Astatoreochromis Pellegrin, 1904.

Astatoreochromis alluaudi Pellegrin.

Pellegrin, 1904, p. 385 ; 1905, p. 185, pl. xvi, fig. 2 ; and 1910, p. 297.
Regan, 1922 (*a*), p. 188.
Haplochromis alluaudi Boulenger, 1915, p. 305, fig. 206.

This species, previously known from Lakes Victoria and Kioga and the Victoria Nile, is now for the first time recorded from the Lake Edward System and Lakes Nakavali and Kachira. Dr. Worthington's collection contains twenty-six specimens, as follows :—

Station 511 (Kazinga Channel), three specimens, 80 to 91 mm. in total length.

Station 567 (Semliki River, above the rapids), one specimen, 102 mm.

Station 618 (Lake George), one specimen, 102 mm.

Stations 802, 807, 812, 815, and 816 (Lake Nakavali), eighteen specimens, 63 to 178 mm.

Station 826 (Lake Kachira), three specimens, 84 to 101 mm.

VII. Haplochromis Hilgendorf, 1888.

Regan, 1922 (*a*), p. 160.

Haplochromis rudolfianus, sp. n.

Depth of body $2\frac{4}{5}$ to $3\frac{2}{5}$ in the length, length of head 3. Snout with straight or slightly convex profile, $3\frac{2}{3}$ to $4\frac{1}{4}$ in length of head, diameter of eye 3 to $3\frac{1}{3}$, depth of praeorbital $6\frac{1}{2}$ to 8, interorbital width $4\frac{1}{4}$ to $4\frac{1}{2}$. Mouth little oblique ; jaws equal anteriorly, lower $2\frac{1}{3}$ to $2\frac{1}{2}$ in length of head ; maxillary extending

to below anterior edge or $\frac{1}{4}$ of eye. Outer teeth bicuspid, larger than inner, which are tricuspid, in 3 or 4 series; 36 to 44 in outer series of upper jaw. 2 or 3 series of scales on the cheek. 8 or 9 gill-rakers on lower part of anterior arch. Lower pharyngeal bone triangular, with teeth small or with a few middle teeth enlarged and blunt. 30 to 31 scales in a longitudinal series, 5 or 6 between origin of dorsal and lateral line, 4 to 6 between pectoral and pelvic fins. Dorsal XIV–XV 9–10; last spine 2 to $2\frac{1}{3}$ in length of head. Anal III 9; third spine as long as last dorsal, or nearly. Pectoral $\frac{3}{4}$ to $\frac{4}{5}$ length of head, reaching vent or origin of anal. Caudal subtruncate. Caudal peduncle $1\frac{1}{4}$ to $1\frac{2}{5}$ as long as deep. A dark vertical bar below eye, one behind it and on the nape; an opercular spot; 6 or 7 vertical stripes below dorsal fin, followed by two series of spots on the caudal peduncle; spots and stripes sometimes united by a more or less continuous horizontal band along side of body; dorsal sometimes with two black blotches on its base; anal with 1 to 3 ocelli.

Lake Rudolf.

Described from five specimens, 49 to 64 mm. in total length, from stations 264 and 285.

Also included in this species are :—

(i.) A specimen of 80 mm. of the correctness of whose label (' Lake Rudolf ') the collectors are uncertain. The eye is relatively smaller ($3\frac{4}{5}$ in the head), the snout longer ($3\frac{1}{3}$ in head), and the interorbital region wider (4 in head), but these are characters attributable to age.

(ii.) 25 young fish of 25 to 46 mm. from stations 264, 285, 289, 290.

Species of Haplochromis *in Lake Nabugabo.*

1. Haplochromis velifer, sp. n.

Depth of body $2\frac{1}{2}$ to $2\frac{4}{5}$ ($2\frac{4}{5}$ to 3 in young) in the length, length of head $2\frac{3}{5}$ to 3. Upper profile straight or very slightly convex. Length of snout 3 to $3\frac{3}{5}$ in length of head, diameter of eye $3\frac{1}{4}$ to $3\frac{2}{3}$ (3 to $3\frac{1}{3}$ in young), depth of praeorbital $4\frac{2}{3}$ to $6\frac{1}{4}$ (6 to $6\frac{2}{3}$ in young), interorbital width 4 to $4\frac{2}{3}$ (to $4\frac{4}{5}$ in young). Mouth with slightly oblique cleft; jaws equal anteriorly, lower $2\frac{1}{3}$ to $2\frac{3}{5}$ ($2\frac{1}{6}$ in 135 mm. specimen) in length of head; maxillary reaching vertical from anterior edge of eye or nearly. Teeth in 3 or 4 series, 40 to 72 in outer series of upper jaw; outer teeth bicuspid, inner bicuspid. 3 or 4 series of scales on the cheek. 6 to 8 gill-rakers on lower part of anterior arch. Lower pharyngeal bone triangular, with small bicuspid teeth. 30 to 32 scales in a longitudinal series, 4 to 6 from origin of dorsal to lateral line, 4 to 6 between pectoral and pelvic fins. Dorsal XV–XVI 9–10; last spine $\frac{1}{3}$ length of head or nearly. Anal III 8–10; third spine $\frac{2}{5}$ to $\frac{1}{2}$ length of head. Pectoral $\frac{3}{4}$ to nearly as long as head, reaching vertical from vent or origin of anal. Caudal

truncate or subtruncate in females, subtruncate or rounded in males. Caudal peduncle from a little longer than deep to $1\frac{2}{5}$ as long. Colour in females silvery, with a vertical stripe below the eye, an opercular spot, and 5 or 6 vertical stripes on the body; in males stripes on body often obscured by dark general coloration, but markings on head clear, including two bars across the snout, one on the occiput and behind the eye and one on the nape; dorsal and anal fins in males dark proximally, with soft dorsal pale distally and with 3 to 5 ocelli on the anal; caudal sometimes spotted; pelvics dark in males. Soft dorsal and anal in males extending for $\frac{1}{4}$ to $\frac{2}{3}$ length of caudal fin beyond its base.

Described from 19 specimens 75 to 135 mm. in total length from Lake Nabugabo. Of these, four, less than 87 mm. in total length, are referred to above as 'young.'

14 specimens, 81 to 92 mm. in total length, from the same lake, also belong to this species, but are not included in the description.

These 33 fishes form a very uniform sample of a Lake Nabugabo community, which, in spite of evident close relationship with certain species of Lakes Victoria and Edward, must be regarded as specifically distinct. It differs from *H. cinereus* in the dentition, the longer snout, and the narrower interorbital region. *H. gestri* has a smaller eye and larger mouth, *H. nubilus* a shorter snout, with the maxillary extending below the eye, and usually a smaller eye and wider interorbital region: *H. schubotzi* has a deeper praeorbital and longer lower jaw.

Two specimens, 83 and 106 mm. long, are referred somewhat doubtfully to this species. The larger has a somewhat stronger lower jaw, and the maxillary ends below the anterior $\frac{1}{4}$ of the eye; in the smaller there are 9 gill-rakers; in both the caudal preduncle is $1\frac{1}{2}$ times as long as deep.

2. Haplochromis annectidens, sp. n.

Depth of body $2\frac{1}{2}$ to $2\frac{4}{5}$ in the length, length of head 3. Upper profile straight. Length of snout $3\frac{1}{6}$ to $3\frac{1}{2}$ in length of head, diameter of eye 3 to $3\frac{1}{3}$, depth of praeorbital 6 to 7, interorbital width $3\frac{3}{4}$ to $4\frac{1}{4}$. Mouth with slightly oblique cleft; jaws equal anteriorly, lower $\frac{2}{5}$ length of head or less; maxillary reaching vertical from anterior edge of eye or nearly. Teeth in 4 to 6 series, inner close-set, tricuspid, separated by a gap from the outer, which are all bicuspid, the anterior long and slender, with the larger cusp inclined towards the symphysis; 42 to 66 in outer series of upper jaw. 2 or 3 series of scales on the cheek. 8 to 10 gill-rakers on lower part of anterior arch. Lower pharyngeal teeth very small and numerous, 11 or 12 in a middle series. 31 or 32 scales in a longitudinal series, 5 from origin of dorsal to lateral line, 3 or 4 between pectoral and pelvic fins. Dorsal XV–XVI 8–10; last spine $\frac{1}{2}$ length of head or more. Anal III 8–10: third spine $\frac{2}{5}$ to $\frac{1}{2}$ length of head. Pectoral $\frac{4}{5}$ to nearly as long as head, extending to above vent or origin of anal. Caudal truncate or with corners very slightly rounded. Caudal peduncle

$1\frac{1}{4}$ to $1\frac{3}{5}$ as long as deep. Colour silvery, with 4 to 6 dark vertical bars on the body and an opercular spot; male with a dark vertical bar below the eye, one behind it and one on the occiput and nape, female with these markings much fainter or absent; dorsal fin clear, in males with a thin dark edge in its spinous part, and with a few spots on the soft-rayed part, often forming stripes between the posterior rays; males with 2 or 3 anal ocelli and with a few spots at base of caudal.

Eleven specimens, 69 to 86 mm. in total length, from Lake Nabugabo. Five of these are males.

This species is closely related to *H. obliquidens*, but in *H. obliquidens* the enlarged oblique teeth have no lateral cusp, and the lateral undifferentiated teeth are fewer and smaller than in *H. annectidens*, and tend to be covered by the folding in of the lip; in the Lake Victoria fish, too, the teeth of the second series tend to lose their cusps and may even become obliquely truncated like the outer teeth, whereas they are always tricuspid in *H. annectidens*. In *H. plagiodon* of Lake Victoria, although the enlarged teeth have kept a lateral cusp, they are much larger and fewer than in the other two species.

The females of *H. annectidens* closely resemble those of *H. velifer* externally, but are easily distinguished by the dentition of jaws and pharyngeals; also the males are very different in coloration. It is probably from a type like *H. velifer* that *H. annectidens, obliquidens*, and *plagiodon* have evolved.

3. Haplochromis beadlei, sp. n.

Depth of body $2\frac{1}{2}$ to $2\frac{2}{3}$ in the length, length of head $2\frac{4}{5}$ to 3. Upper profile straight. Length of snout 3 to $3\frac{1}{2}$ in length of head, diameter of eye $3\frac{1}{2}$ to 4, depth of praeorbital $5\frac{1}{2}$ to $6\frac{1}{2}$, interorbital width 4 to $4\frac{1}{2}$. Mouth broader than long, with slightly oblique cleft; lips thick; jaws equal in front, or lower slightly projecting; lower $2\frac{1}{2}$ to $2\frac{2}{3}$ in length of head; maxillary ending at vertical between nostril and eye, or below nostril. Teeth in 3 or 4 series in upper jaw, 4 or 5 in lower, outer bicuspid, or a few simple enlarged separated by a gap from the inner, which are small and tricuspid; 22 to 34 in outer series of upper jaw. 2 to 4 series of scales on the cheek. 7 to 9 gill-rakers on lower part of anterior arch. Lower pharyngeal teeth small, bicuspid, not very numerous, those near middle line occasionally enlarged, 8 to 10 in a middle series. 30 or 31 scales in a longitudinal series, 5 or 6 from origin of dorsal to lateral line, 4 or 5 between pectoral and pelvic fins. Dorsal XV–XVI 9–10 (one specimen with XVI 7, the last ray stunted, abnormal); last spine $2\frac{1}{5}$ to $2\frac{1}{2}$ in length of head. Anal III 9–10; third spine $2\frac{1}{3}$ to $2\frac{2}{3}$ in length of head. Pectoral $\frac{3}{4}$ to nearly as long as head, reaching vent or anal fin. Caudal subtruncate or, rarely, truncate. Caudal peduncle as long as deep or a little longer. Colour silvery, with a bar below the eye, an opercular spot, and six or seven faint vertical stripes, accentuated or united along lower lateral line and posterior half of upper. Male with spinous dorsal dusky and soft dorsal pale or with light ocellar spots which may merge into stripes

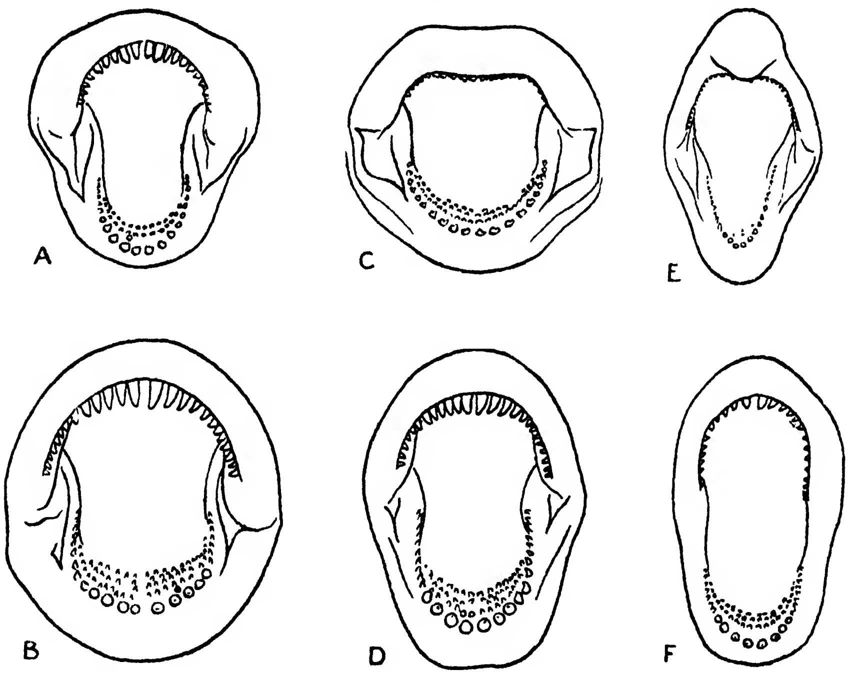
between the rays; with caudal yellow with a dark base; with anal yellow, with 3 or 4 ocelli; and with outer half of pelvics black, inner half probably yellow. Males also have a vertical bar behind the eye and bars across occiput and nape. In the females, caudal and soft dorsal may be spotted, and the anal may have 2 to 9 small ocellar spots.

Lake Nabugabo.

Twelve specimens, 92 to 130 mm. in total length, from Lake Nabugabo. Two young fishes, 28 and 30 mm. long, may also be included here.

Named in honour of Mr. L. C. Beadle, chemist and zoologist on the Expedition.

TEXT-FIG. 5.



Jaws and teeth of: A. *Haplochromis crassilabris*, one of the types, 105 mm. long. B. *H. crassilabris*, 148 mm. specimen. C. *H. beadlei*, 130 mm. specimen. D. *H. labiatus*, 134 mm. specimen. E. *H. chilotes*, type, 87 mm. F. *H. paucidens* (Lake Kivu), one of the types, 115 mm. long. All ×2½. The lower jaw shows the arrangement of the teeth, the upper the shape of the outer teeth.

This species is closely related to *H. sauvagei* and *H. crassilabris* of Lake Victoria, being intermediate in the number of teeth. The inner teeth never form broad bands of close-set teeth as in *H. sauvagei*, and the snout and lower jaw are usually longer than in *H. crassilabris* of the same size.

4. HAPLOCHROMIS PELLEGRINI Regan.

Regan, 1922 (*a*), p. 185, text-fig. 11.

Seven specimens, 133 to 214 mm. in total length, from Lake Nabugabo.

The smallest of these is about the same size as the types. As the new specimens form a well-graded series, a description of them is given.

Depth of body about 3 in the length, length of head $2\frac{3}{8}$ to 3 (longest in the largest fish). Upper profile of snout straight or concave. Snout $1\frac{1}{3}$ to $1\frac{3}{4}$ diameter of eye, $2\frac{3}{8}$ to nearly 3 in length of head, diameter of eye $4\frac{1}{4}$ to 5, depth of praeorbital 5 to $5\frac{1}{2}$, interorbital width $4\frac{3}{4}$ to $5\frac{3}{5}$. Cleft of mouth oblique; maxillary reaching vertical from anterior edge of eye, or nearly; lower jaw projecting, $\frac{1}{2}$ length of head or more. Teeth conical, in 3 series, 42 to 66 in outer series of upper jaw. 2 to 4 series of scales on the cheek. 8 or 9 gill-rakers on lower part of anterior arch. Lower pharyngeal teeth small, bicuspid, 10 to 13 in a middle series. 31 scales in a longitudinal series, 5 or 6 from origin of dorsal to lateral line, 5 between pectoral and pelvic fins. Dorsal XIV–XVI 9–10; last spine $2\frac{1}{2}$ to $3\frac{1}{4}$ in length of head. Anal III 9–10; third spine stronger than last dorsal, $\frac{1}{3}$ length of head. Pectoral $\frac{3}{4}$ length of head, extending to above vent or anal spines. Caudal truncate. Caudal peduncle $1\frac{1}{3}$ as long as deep. Silvery, darker above: an opercular spot; fins clear, or dorsal and caudal with indistinct spots, or vertical fins dark proximally and distally, with an intervening pale stripe; male with dark pelvics, and with three ocelli on the anal.

Species of Haplochromis *in Lakes Edward (and George), Nakavali, Kachira, and Kijanebalola.*

Synopsis.

I. Snout less than $\frac{1}{3}$ length of head.
  A. Teeth cuspidate, in 5 to 8 series, the inner not separated by a distinct interspace from the outer .... 1. *serridens*.
  B. Inner series of teeth separated by a wider interspace from the outermost than from each other.
    1. Teeth in 5 to 7 series (in adult), the inner well-developed, tricuspid.
      Caudal truncate; diameter of eye 3 to $3\frac{1}{3}$ in length of head. 2. *limax*.
      Caudal rounded; diameter of eye $3\frac{1}{2}$ to 4 in length of head. 3. *fuscus*.
    2. Teeth in 2 to 4 series, cuspidate or conical.
      a. Caudal peduncle deeper than long; 6 or 7 gill-rakers on lower part of anterior arch .... 4. *multicolor*.
      b. Caudal peduncle longer than deep.
        (i.) Teeth small, more than 30 in outer series of upper jaw.
          α. Interorbital width $3\frac{1}{2}$ to $4\frac{1}{2}$ in length of head; caudal subtruncate; diameter of eye $3\frac{3}{5}$ to $4\frac{1}{6}$ in length of head .... 5. *nubilus*.
          β. Interorbital width $3\frac{1}{3}$ to $4\frac{1}{2}$ in length of head; caudal truncate or slightly emarginate.
            * Lower pharyngeal teeth small, or, at the most, a few slightly enlarged.
              † Maxillary extending to below anterior $\frac{1}{4}$ of eye.

Depth of body $3\frac{1}{4}$ to $3\frac{1}{2}$ in the length; lower jaw $2\frac{1}{4}$ to $2\frac{1}{3}$ in length of head; 10 or 11 gill-rakers on lower part of anterior arch .... 6. *nigripinnis*.

Depth of body $2\frac{1}{4}$ to $2\frac{3}{4}$ in the length; lower jaw $2\frac{1}{8}$ to $2\frac{1}{2}$ in length of head; 8 to 10 gill-rakers on lower part of anterior arch .... 7. *vicarius*.

Depth of body 3 in the length; lower jaw $2\frac{3}{4}$ in length of head; 7 or 8 gill-rakers on lower part of anterior arch .... 8. *engystoma*.

†† Maxillary extending to, or a little beyond, vertical from anterior edge of eye.

Depth of body $2\frac{2}{3}$ to 3 in the length; lower jaw $2\frac{1}{2}$ to $2\frac{3}{4}$ in length of head in fishes of 86 mm. or less, $2\frac{1}{4}$ to $2\frac{1}{2}$ in larger specimens; gill-rakers slender, 9 to 12 on lower part of anterior arch .... 9. *eduardii*.

††† Maxillary ending below anterior edge of eye.

Depth of body $2\frac{2}{3}$ to 3 in the length; lower jaw $2\frac{1}{2}$ to $2\frac{3}{4}$ in length of head; gill-rakers short, 8 or 9 on lower part of anterior arch .... 10. *elegans*.

Depth of body more than 3 in the length; lower jaw $2\frac{1}{3}$ to $2\frac{1}{2}$ in length of head; gill-rakers slender, 9 or 10 on lower part of anterior arch........... 11. *macrops*.

†††† Maxillary not reaching vertical from anterior edge of eye. 12. *pappenheimi*.

** Lower pharyngeal massive, with enlarged blunt teeth. 13. *ishmaeli*.

γ. Interorbital width $4\frac{2}{3}$ to 5 in length of head........ 14. *angustifrons*.

(ii.) Teeth rather stout, not more than 30 in outer series of upper jaw, in specimens up to 164 mm. in total length.

Lips thick, mobile, in adults slightly lobed; lower jaw $2\frac{2}{3}$ to 3 in length of head .... 15. *labiatus*.

Lips not greatly thickened: lower jaw 2 to $2\frac{1}{4}$ in length of head 16. *taurinus*.

II. Snout 3 to $3\frac{1}{2}$ in length of head, lower jaw $2\frac{1}{3}$ to $2\frac{2}{3}$ .... 17. *schubotzi*.

III. Snout $2\frac{1}{2}$ to 3 in length of head, lower jaw $1\frac{2}{3}$ to $2\frac{1}{4}$.

A. Maxillary extending to below anterior $\frac{1}{3}$ of eye............. 18. *dolorosus*

B. Maxillary extending to vertical from anterior edge of eye or nearly.

1. Scales on some of the rays of dorsal and anal fins .... 19. *squamipinnis*.
2. No scales on dorsal and anal fins.

5 scales between pectoral and pelvic fins .... 20. *mentatus*.

6 to 8 scales between pectoral and pelvic fins .... 21. *guiarti* *.

1. Haplochromis serridens Regan.

Regan, 1925, p. 187, pl. viii.

Depth of body $2\frac{2}{3}$ to 3 in the length, length of head 3 to $3\frac{1}{3}$. Snout decurved, $3\frac{2}{3}$ to 4 in length of head, diameter of eye $3\frac{1}{4}$ to $3\frac{1}{3}$, depth of praeorbital 6 to $6\frac{1}{2}$, interorbital width $3\frac{1}{4}$ to $3\frac{1}{2}$. Jaws equal anteriorly, lower $2\frac{2}{3}$ to $2\frac{3}{4}$ in length of head; maxillary extending to below anterior edge of eye. Teeth in 5 to 8 series, outer bicuspid, inner tricuspid, 42 to 50 in outer series of upper jaw. 2 or 3 series of scales on the cheek. 7 to 10 gill-rakers on lower part of anterior arch. Lower pharygeal teeth small, slender, bicuspid, 6 to 9 in a middle series. 31 to 33 scales in a longitudinal series, 5 or 6 from origin of dorsal to lateral

* For the purposes of this key only the Lake Edward specimens of this species have been checked.

line, the same number between pectoral and pelvic fins. Dorsal XV–XVI 9–10; last spine $\frac{2}{5}$ to more than $\frac{1}{2}$ length of head. Anal III 9; third spine a little shorter than last dorsal. Pectoral as long as or a little shorter than head, reaching vent or anal fin. Caudal very slightly emarginate, with rounded corners. Caudal peduncle $1\frac{1}{3}$ as long as deep. Silvery, darker above; an opercular spot, and sometimes traces of six or seven vertical stripes on body.

Description modified from the original diagnosis; one of the types and two additional specimens (coll. Worthington), 87 and 92 mm. in total length, from Lake Edward, examined.

Haplochromis serridens is closely related to *H. nigricans* and *H. nuchisquamulatus* of Lake Victoria, and represents both these species in the Lake Edward fauna.

2. Haplochromis limax, sp. n.

Depth of body $2\frac{2}{3}$ in the length, length of head 3. Upper profile of snout straight. Snout $3\frac{3}{4}$ in length of head, diameter of eye $3\frac{1}{3}$, depth of praeorbital $7\frac{1}{3}$, interorbital width $3\frac{2}{3}$. Mouth with oblique cleft; jaws equal anteriorly, lower $2\frac{3}{5}$ in length of head; maxillary ending below anterior edge of eye. Teeth in 6 or 7 series, 44 in outer series of upper jaw; outer bicuspid, inner well-developed, tricuspid. 3 series of scales on cheek. 10 gill-rakers on lower part of anterior arch, the two lowest minute. Lower pharyngeal teeth small, bicuspid, the posterior middle tooth slightly enlarged; 9 or 10 in a middle series. 31 or 32 scales in a longitudinal series, 5 from origin of dorsal to lateral line, 6 between bases of pectoral and pelvic fins. Dorsal XV 10; last spine $2\frac{1}{5}$ in length of head. Anal III 9; third spine $2\frac{3}{5}$ in length of head. Pectoral a little shorter than head, ending above vent. Caudal truncate. Caudal peduncle a little longer than deep. Colour silvery, darker on nape; faint traces of bars on snout and below eye; an opercular spot; pelvics dark; two ocellii on the anal fin.

Lake Edward.

Described from a single specimen, a male, 98 mm. in total length (Worthington).

Three smaller fishes, 77 to 80 mm. long (Worthington), and two of 64 mm. in the collection of the Natural History Museum, perhaps belong to this species. In them the teeth are in 4 series and the diameter of the eye is $\frac{1}{3}$ of the length of the head.

The type is distinguished from a specimen of *H. vicarius* of the same length by the smaller eye (more than $\frac{1}{3}$ in *H. vicarius*) and deeper praeorbital ($8\frac{1}{4}$ in length of head in *H. vicarius*), as well as by the broad bands of teeth. The younger specimens are distinguished with more difficulty, but still have a smaller eye than specimens of *H. vicarius* of the same size.

The species is most nearly related to *H. macrops*, but has a somewhat deeper body, as well as the distinct dentition.

3. HAPLOCHROMIS FUSCUS Regan.

Regan, 1925, p. 187, pl. IX.

Known only from the types, three specimens, 80 to 95 mm. in total length, one of which is in the British Museum (Nat. Hist.).

4. HAPLOCHROMIS MULTICOLOR (Hilgendorf).

Paratilapia multicolor Hilgendorf, 1903, p. 429.
Haplochromis strigigena (part.) Boulenger, 1915, p. 299, fig. 203.
Haplochromis multicolor Regan, 1922 (*b*), p. 260.

Thirty-one specimens, 25 to 78 mm. in total length, from the River Semliki (station 567) and Lake Kijanebalola (stations 828, 832, and 836).

The fifteen specimens from Station 832 were taken from stomachs of darters. Eight others from this lake were 72 to 78 mm. in total length, thus larger than previously described specimens, which have been taken from the Nile, and a brief description of them is therefore appended.

Depth of body 2$\frac{3}{5}$ to 2$\frac{2}{3}$ in the length, length of head nearly 3. Diameter of eye 4 to 4$\frac{1}{2}$ in length of head, interorbital width 3, depth of praeorbital 6$\frac{3}{4}$ to 7. Maxillary reaching vertical from anterior edge of eye or nearly. Teeth in 3 series, 34 to 46 in outer series of upper jaw ; inner feebly tricuspid, outer unequally bicuspid in front, conical in upper jaw near corner of mouth, occasionally a few simple in lower jaw. Three series of scales on the cheek. 6 or 7 short gill-rakers on lower part of anterior arch. Lower pharyngeal teeth pointed, bicuspid, 7 to 9 in a middle series. 26 to 28 scales in a longitudinal series, 3 or 4 between origin of dorsal and lateral line, 4 or 5 between pectoral and pelvic fins. Dorsal XIV–XV 8–10 ; last spine from a little more than $\frac{1}{3}$ to $\frac{2}{5}$ length of head. Anal III 8–9 ; third spine about $\frac{1}{3}$ length of head.

5. HAPLOCHROMIS NUBILUS (Boulenger), 1906.

Regan, 1922 (*a*), p. 164.

(i.) 51 specimens, 54 to 93 mm. in total length, from Lakes Edward and George, taken at stations 567 (shore seine in Semliki River), 573 (East shore of Lake Edward), 521 (Lake Edward, mouth of Kazinga Channel), 511 (Kazinga Channel), 613, and 618 (Lake George), thus only from the shallower parts of this system.

(ii.) Eight specimens, 67 to 104 mm. long, from Lake Nakavali, five of these taken by a shore seine (station 802), one among weeds (station 812), and 2 from the stomachs of darters (station 815).

(iii.) Twenty-three specimens, 42 to 88 mm. in total length, from Lake Kijanebalola, sixteen of these from darter stomachs (station 832), the rest from station 828.

(iv.) Five specimens from Lake Kachira (station 826).

In the Lake Edward specimens there is a tendency for the scales on the chest to be smaller and more numerous than in specimens from Lake Victoria.

This is shown by the number of scales between the pectoral and pelvic fins in a sample of twenty from each lake. In the Lake Victoria sample there are 6 in 1 specimen, 5 in 10, 4 in 6, and 3 in 3 ; in the Lake Edward sample there are 6 in 7 specimens, 5 in 11, 4 in 2. In males from Lake Edward the depth of the body is often somewhat greater in proportion to the length than in Lake Victoria specimens of the same size, and the caudal peduncle is less slender.

In the (small) specimens from Lake Kijanebalola the corresponding scale count is 3 or 4, in the Lake Nakavali specimens 4 or 5. The specimens from both these lakes resemble in proportions the Lake Victoria type rather than the Lake Edward type.

6. Haplochromis nigripinnis Regan.

Tilapia pappenheimi (part.) Boulenger, 1914, p. 254, and 1915, p. 232.
Tilapia martini (part.) Boulenger, 1914, p. 255, and 1915, p. 239.
Haplochromis nigripinnis Regan, 1921, p. 635.

Depth of body $3\frac{1}{6}$ to $3\frac{1}{3}$ in the length, length of head 3 to $3\frac{1}{6}$. Upper profile slightly decurved. Snout 4 to $4\frac{1}{4}$ in length of head, diameter of eye $2\frac{3}{4}$, depth of praeorbital $7\frac{1}{4}$ to $7\frac{1}{2}$, interorbital width $4\frac{1}{2}$. Jaws equal anteriorly, or lower very slightly in advance ; cleft of mouth somewhat oblique ; lower jaw $2\frac{1}{4}$ to $2\frac{1}{3}$ in length of head ; maxillary ending below anterior $\frac{1}{4}$ of eye. Teeth in 2 or 3 series, outer bicuspid, inner tricuspid, 45 or 46 in outer series of upper jaw. 3 series of scales on cheek. 10 or 11 gill-rakers on lower part of anterior arch.

Pharyngeal teeth small, slender, bicuspid, 10 in a middle series. 32 or 33 scales in a longitudinal series, 4 or 5 from origin of dorsal to lateral line, and the same number between pectoral and pelvic fins. Dorsal XV–XVI 9 ; last spine 2 to $2\frac{3}{5}$ in length of head. Anal III 8–9 ; third spine as long as last dorsal. Pectoral $\frac{4}{5}$ to nearly as long as head, reaching vent. Caudal truncate. Caudal peduncle $1\frac{1}{2}$ as long as deep. Colour in female silvery, all markings faded in alcohol ; male darker, with dark vertical and pelvic fins, the anal with a large ocellus.

Described from the type, a male 80 mm. long, and from a female of 85 mm. included by Boulenger in *Tilapia martini*.

H. nigripinnis is more slender than *H. cinereus*, and has a shorter head.

7. Haplochromis vicarius, sp. n.

Depth of body $2\frac{1}{2}$ to $2\frac{3}{4}$ in the length, length of head $2\frac{4}{5}$ to 3. Snout with straight or slightly convex profile, $3\frac{1}{2}$ to 4 in length of head, diameter of eye $2\frac{2}{3}$ to $3\frac{1}{3}$, depth of praeorbital 7 to $8\frac{1}{2}$, interorbital width $3\frac{1}{3}$ to $4\frac{1}{4}$. Jaws equal, or lower very slightly projecting ; lower $2\frac{1}{5}$ to $2\frac{1}{2}$ in length of head ; mouth with somewhat oblique cleft ; maxillary ending below anterior $\frac{1}{4}$ of eye. Teeth in 3 or 4 series, outer bicuspid (some conical in largest specimen), inner tricuspid, 44 to 60 in outer series of upper jaw. 2 or 3 series of scales on the

cheek. 8 to 10, usually 9 or 10 gill-rakers on lower part of anterior arch. Lower pharyngeal teeth small, bicuspid, or a few posterior middle teeth slightly enlarged, 8 to 12 in a middle series. 30 to 33 scales in a longitudinal series, 4 to 6 from origin of dorsal to lateral line, 4 to 6 between pectoral and pelvic fins. Dorsal XIV–XVI 9–10 ; last spine $\frac{1}{2}$ length of head or less. Anal III 8–9 ; third spine $2\frac{1}{5}$ to $2\frac{2}{5}$ in length of head. Pectoral $\frac{5}{6}$ to as long as head, reaching origin of anal or beyond. Caudal truncate or slightly emarginate. Caudal peduncle from a little longer than deep to $1\frac{2}{5}$ as long. Colour in females silvery, with an opercular spot, occasionally with faint traces of about six vertical stripes on the body, and with caudal and soft dorsal spotted ; males similar, but darker, with dark pelvics and two or (rarely) 3 large ocelli on the anal fin.

Lakes Edward and George.

Described from 21 specimens, 78 to 110 mm. in total length from Stations 551, 553, 573, 613, from the East shore of Lake Edward, and from a station of which the number is lost.

Five young fish, 54 to 78 mm. long, also belong to this species. They are from Stations 511, 573, 613, and from the East shore of Lake Edward. Two specimens, 51+? and 72 mm. long, in the collection of the Natural History Museum are also included.

This species is near *H. cinereus* of Lake Victoria, but differs in the more oblique mouth and narrower praeorbital, and in the dentition, which in *H. cinereus* of 94 mm. consists of slender conical teeth only. It has a larger eye and narrower praeorbital than *H. macrops*.

8. Haplochromis engystoma, sp. n.

Tilapia martini (part.) Boulenger, 1914, p. 255, and 1915, p. 239.
Haplochromis schubotzi (part.) Regan, 1921, p. 634.

Depth of body 3 in the length, a little greater than length of head. Snout decurved, $4\frac{3}{4}$ in length of head, diameter of eye $2\frac{3}{4}$, depth of praeorbital $7\frac{1}{3}$, interorbital width nearly $4\frac{1}{2}$. Cleft of mouth nearly horizontal ; lower jaw a little shorter than upper in front, $2\frac{3}{4}$ in length of head ; maxillary ending below anterior $\frac{1}{4}$ of eye. Teeth in three series, outer bicuspid, inner tricuspid ; 36 in outer series of upper jaw. 7 or 8 gill-rakers on lower part of anterior arch. Pharyngeal teeth small, bicuspid. 32 scales in a longitudinal series, 6 from origin of dorsal to lateral line, 6 between pectoral and pelvic fins. Dorsal XV 10 ; last spine nearly half length of head. Anal III 10 ; third spine as long as last dorsal. Pectoral a little shorter than head, ending above origin of anal. Caudal ? (incomplete). Caudal peduncle $1\frac{2}{5}$ as long as deep. Silvery ; soft dorsal and caudal spotted ; a faint ocellus on the anal fin.

Lake Edward.

Described from a single specimen, 86 mm. in total length (coll. Schubotz).

A specimen of 56 mm. (coll. Schubotz) is also included in this species.

This species is distinguished from *H. angustifrons* and *H. vicarius* by the short lower jaw, from *H. eduardii* by the gill-rakers, which are shorter and fewer, and from *H. elegans* by the larger eye.

9. Haplochromis eduardii Regan.

Haplochromis pappenheimi (part.) Boulenger, 1914, p. 254, and 1915, p. 232.
Tilapia martini (part.) Boulenger, 1914, p. 255, and 1915, p. 239.
Haplochromis schubotzi (part.) Regan, 1921, p. 634.
Haplochromis eduardii Regan, 1921, p. 635.

Depth of body $2\frac{3}{4}$ to 3 in the length, length of head 3 to $3\frac{1}{5}$. Upper profile of snout slightly convex. Length of snout 3 to $4\frac{1}{2}$ in length of head, diameter of eye 3 to $3\frac{3}{4}$ ($2\frac{3}{4}$ in a 73 mm. specimen), depth of praeorbital $5\frac{1}{2}$ to $7\frac{1}{2}$, interorbital width $3\frac{1}{2}$ to $4\frac{1}{2}$. Jaws equal anteriorly, or lower very slightly projecting, lower $2\frac{1}{4}$ to $2\frac{3}{4}$ in length of head ($2\frac{1}{2}$ to $2\frac{3}{4}$ in specimens of 100 mm. or less); maxillary extending to vertical from anterior edge of eye, or a little beyond. Teeth in 2 to 4 series, conical in large specimens, outer bicuspid, inner tricuspid in small, 38 to 65 in outer series of upper jaw. 3 or 4 series of scales on the cheek. 9 to 12 slender gill-rakers on lower part of anterior arch. Lower pharyngeal teeth small, slender, bicuspid, 9 to 11 in a middle series. 31 to 34 scales in a longitudinal series, 5 to 7 from origin of dorsal to lateral line, 6 to 8 between bases of pectoral and pelvic fins. Dorsal XV–XVI 9–10; last spine $\frac{2}{5}$ to $\frac{1}{2}$ length of head. Anal III 8–9; third spine $\frac{1}{3}$ to nearly $\frac{1}{2}$ length of head. Pectoral as long as head, or nearly, reaching vent or origin of anal. Caudal truncate. Caudal peduncle $1\frac{1}{4}$ to $1\frac{1}{2}$ as long as deep. Five or six vertical bars on the body; in some specimens two dark bars across the snout, a vertical bar below the eye, an oblique bar behind it, and an opercular spot; rarely an interrupted lateral band. Sometimes two black blotches at base of dorsal. In males anal with 2 to 5 ocelli and pelvics dark.

Lake Edward.

Described from ten specimens, 73 to 145 mm. in total length, namely, the type, 80 mm., three specimens, 73 to 81 mm., named '*T. martini*' by Boulenger and *H. schubotzi* by Regan, and six specimens, 80 to 145 mm. (coll. Worthington), from Lake Edward.

This species is very close to *H. melanopus* of Lake Victoria, and individual specimens of either species may be difficult to distinguish from the other. Specimens of *H. melanopus*, however, are usually less slender than *H. eduardii* of the same size, and have a somewhat smaller eye and deeper praeorbital. In the types of *H. melanopus* the scales between pectoral and pelvic fins number 5 to 7, usually 5 or 6, and the gill-rakers are not fewer than 11 (Regan, 1922 (*a*), p. 165).

10. Haplochromis elegans, sp. n.

Depth of body $2\frac{3}{5}$ to 3 in the length, length of head 3. Snout with upper profile slightly decurved, $3\frac{1}{3}$ to 4 in length of head, diameter of eye 3 to $3\frac{1}{4}$,

depth of praeorbital $6\frac{1}{3}$ to $7\frac{1}{3}$, interorbital width 4 to $4\frac{1}{2}$. Cleft of mouth slightly oblique ; jaws weak, equal anteriorly, lower $2\frac{1}{2}$ to $2\frac{3}{4}$ in length of head ; maxillary reaching vertical from anterior edge of eye or nearly. Teeth in 3 or 4 series, outer bicuspid, inner tricuspid ; 34 to 44 in outer series of upper jaw. 2 or 3 series of scales on the cheek. Gill-rakers short, 8 or 9 on lower part of anterior arch. Lower pharyngeal teeth small bicuspid, 9 or 10 in a middle series, of which a few posterior may be somewhat enlarged. 30 or 31 scales in a longitudinal series, 4 to 6 between origin of dorsal and lateral line, 5 to 7 between pectoral and pelvic fins. Dorsal XIV–XVI 8–10 ; last spine 2 to $2\frac{1}{4}$ in length of head. Anal III 8–10 ; third spine as long as last dorsal, or nearly. Pectoral as long as head, or nearly, reaching origin of anal fin. Caudal truncate or with rounded corners. Caudal peduncle a little longer than deep. Colour silvery, with an opercular spot. Breeding males darker, with two dark bars across the snout, one below the eye and one on the praeoperculum, with throat and belly dusky ; anal dusky, with two or three ocelli · dorsal with dark edge, or spotted ; caudal spotted ; pelvics dark.

Lakes Edward and George, and Kazinga Channel.

Described from nine specimens (coll. Worthington), 76 to 85 mm. in total length. Three of these are females, from Lake George, the rest are males.

Seven young fishes, 55 to 63 mm., from Stations 522 and 613 also belong to this species.

H. elegans differs from *H. eduardii* in having fewer and shorter gill-rakers, and from *H. cinereus* in the small weak lower jaw and shorter mouth.

11. Haplochromis macrops (Boulenger).

Tilapia macrops Boulenger, 1911, p. 73, pl. III. fig. 1, and 1915, p. 238, fig. 157.
Haplochromis macrops Regan, 1922 (*a*), p. 166.

This species was first described from Lake Victoria, but two specimens, now in Berlin, were recorded from Lake Edward by Boulenger in 1914. A description follows of a specimen, 97 mm. in total length, from Lake Edward (coll. Worthington, Station 565).

Depth of body nearly $\frac{1}{3}$ of the length, equal to length of head. Upper profile very slightly convex. Snout $3\frac{1}{3}$ in length of head, equal to diameter of eye, depth of praeorbital $6\frac{1}{2}$, interorbital width $3\frac{2}{3}$. Cleft of mouth somewhat oblique : jaws equal anteriorly, the lower $2\frac{1}{3}$ in length of head ; maxillary ending below anterior edge of eye. Teeth in 3 or 4 series, outer bicuspid, inner tricuspid, 56 in outer series of upper jaw. 2 or 3 series of scales on the cheek. 9 or 10 gill-rakers on lower part of anterior arch. Lower pharyngeal teeth small, bicuspid, 9 in a middle series. 30 scales in a longitudinal series, 5 from origin of dorsal to lateral line, 5 between pectoral and pelvic fins. Dorsal XV 10 ; last spine $2\frac{1}{4}$ in length of head. Anal III 9 ; third spine $2\frac{2}{3}$ in length of head. Pectoral a little shorter than head, ending above vent. Pelvic ending in a short filament. Caudal truncate. Caudal peduncle $1\frac{2}{3}$ as long as deep.

Colour silvery, darker above; an opercular spot; seven or eight dark vertical stripes on the body.

This specimen differs from *H. eduardii* and resembles the types of *H. macrops* in having relatively few and large scales on the chest. The eye is a little smaller and the praeorbital deeper than in *H. vicarius* of the same size.

12. Haplochromis pappenheimi (Boulenger).

Tilapia pappenheimi Boulenger, 1914, p. 254, pl. vii, fig. 1, and 1915, p. 232, fig. 153.
Haplochromis pappenheimi Regan, 1921, p. 634.

Depth of body $3\frac{1}{4}$ to $3\frac{1}{2}$ in the length, length of head $3\frac{1}{5}$ to $3\frac{1}{3}$. Upper profile of snout straight or slightly decurved. Snout as long as diameter of eye, which is $3\frac{1}{2}$ in length of head, depth of praeorbital $5\frac{1}{2}$ to 6, interorbital width $3\frac{1}{2}$ to 4. Mouth oblique, lower jaw slightly projecting, $2\frac{1}{3}$ to $2\frac{1}{2}$ in length of head; maxillary not reaching vertical from anterior edge of eye. Teeth in 2 or 3 series, inner tricuspid, outer bicuspid, 40 to 46 in outer series of upper jaw. 3 or 4 series of scales on the cheek. 9 to 11 gill-rakers on lower part of anterior arch. Lower pharyngeal teeth small, slender, bicuspid, 9 in a middle series. 33 scales in a longitudinal series, 6 or 7 from origin of dorsal to lateral line, 5 or 6 between pectoral and pelvic fins. Dorsal XV–XVI 9–10; last spine $\frac{2}{5}$ length of head. Anal III 8–9; third spine $\frac{1}{3}$ to $\frac{2}{5}$ length of head. Pectoral nearly as long as head, reaching vent or anal fin. Caudal truncate. Caudal peduncle $1\frac{1}{2}$ to $1\frac{3}{4}$ as long as deep. Colour silvery; caudal spotted.

Four specimens, types of the species, 80 to 90 mm. long, from Lake Edward. These are all females, two with young in the mouth. The species is not represented in the new collection.

13. Haplochromis ishmaeli Boulenger, 1906.

Haplochromis ishmaeli Regan, 1922 (*a*), p. 169.

Previously known only from Victoria Nyanza.

Two specimens, a male and a female, each 147 mm. in total length, from Lake Edward (station 572), agree very well with specimens from Lake Victoria, but the eye is a little larger, and the caudal peduncle less slender than in Lake Victoria specimens of the same size. There are only five well-developed gill-rakers on the lower part of the anterior arch, with two additional rudiments in one specimen. Some of the Lake Victoria specimens in the British Museum (Nat. Hist.) have only seven, with the lower two very small.

14. Haplochromis angustifrons Boulenger, 1914.

Haplochromis angustifrons (part.) Boulenger, 1915, p. 292, fig. 198.
Haplochromis spekii (part.) Boulenger, t.c. p. 416.
Haplochromis schubotzi (part.) Regan, 1921, p. 634.

Depth of body $2\frac{1}{2}$ to $2\frac{4}{5}$ in the length, length of head $2\frac{3}{4}$ to 3. Snout $\frac{3}{4}$ to as long as diameter of eye, which is 3 to $3\frac{1}{2}$ in length of head, depth of praeorbital

$5\frac{2}{5}$ to 6, interorbital width $4\frac{3}{5}$ to 5. Jaws equal, lower $2\frac{1}{3}$ to $2\frac{2}{3}$ in length of head; maxillary extending to below anterior $\frac{1}{4}$ of eye. Teeth in 3 or 4 series, outer conical or (in young) bicuspid, inner simple or tricuspid, 50 to 60 in outer series of upper jaw. 3 series of scales on cheek. 7 or 8 gill-rakers on lower part of anterior arch. Lower pharyngeal with teeth of middle series slightly enlarged, in older specimens some with worn crowns, the rest bicuspid; 10 to 12 in middle series. 30 to 33 scales in a longitudinal series, 4 to 6 from origin of dorsal to lateral line, 7 between pectoral and pelvic fins. Dorsal XIV–XV 9–11; last spine 2 to $2\frac{2}{5}$ in length of head. Anal III 9; third spine $2\frac{2}{5}$ to 3 in length of head. Pectoral $\frac{3}{4}$ to as long as head, reaching anal fin. Caudal ? (incomplete). Caudal peduncle $1\frac{1}{4}$ to $1\frac{1}{2}$ as long as deep. Colour silvery.

Lakes Edward and George.

Described from three of the types, 84 to 100 mm. in total length, from a specimen of 109 mm., named *H. spekii* by Boulenger, all collected by Dr. H. Schubotz, and from a specimen of 80 mm. collected by Dr. Worthington.

This species differs from *H. schubotzi* in having a shorter snout, with the maxillary ending more posteriorly, and in having the interorbital region narrower than in *H. schubotzi* of the same size.

Two young fishes, 55 and 61 mm. in total length, from Lake George, are included in this species. They agree with the above description, except in having fewer teeth; the smaller fish also has a narrower praeorbital.

15. Haplochromis labiatus, sp. n.

Depth of body $2\frac{2}{5}$ in the length, length of head 3. Snout declivous, $3\frac{2}{3}$ in length of head, diameter of eye 4, depth of praeorbital $5\frac{2}{3}$, interorbital width $4\frac{1}{4}$. Mouth small, narrow, very slightly oblique, with thick mobile lips; lower jaw a little shorter than upper, $\frac{1}{3}$ length of head; maxillary not extending to eye. Teeth rather bluntly conical, in 4 series anteriorly; outer and anterior teeth considerably larger than inner and posterior, 27 in outer series of upper jaw (see text-fig. 5, p. 325). 3 series of scales on cheek. 7 or 8 gill-rakers on lower part of anterior arch. Lower pharyngeal bone triangular, with short anterior blade, with teeth strong, the middle enlarged and blunt. 32 scales in a longitudinal series, 5 from origin of dorsal to lateral line, 8 between pectoral and pelvic fins. Dorsal XVI 10; last spine $2\frac{1}{5}$ in length of head. Anal III 10; third spine $2\frac{1}{2}$ in length of head. Pectoral as long as head, reaching beyond origin of anal. Caudal truncate. Caudal peduncle $1\frac{1}{6}$ as long as deep. Colour silvery; an opercular spot; 5 faint vertical stripes on body; soft dorsal and anal fins dusky near base; pelvics dark.

Lake Edward.

Described from a single specimen, 136 mm. in total length, from station 524.

Two specimens, 76 and 94 mm. in total length, are also referred to this species. Their differences from the type are mainly to be regarded as juvenile characters. Diameter of eye 3 to $3\frac{1}{2}$ in length of head, depth of praeorbital $6\frac{1}{2}$, interorbital width $3\frac{4}{5}$ to 4, lower jaw $2\frac{3}{4}$. Outer teeth bicuspid, inner feebly

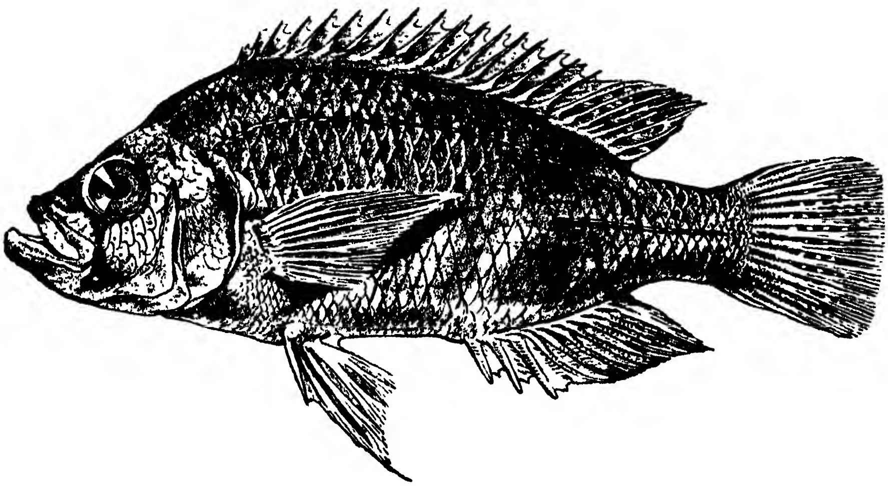
tricuspid, 26 or 28 in outer series of upper jaw. A ninth minute gill-raker on the lower part of the anterior arch in one specimen. D XV–XVI 9. A III 9.

This species appears to represent in Lake Edward *H. sauvagei* and *H. crassilabris* of Lake Victoria, being intermediate in the number and size of the outer teeth; but the mouth is narrower in the adult, and the lips slightly more mobile than in either of these, and in this respect it makes some approach to the more highly specialized condition found in *H. chilotes*.

16. HAPLOCHROMIS TAURINUS, sp. n. (Text-fig. 6.)

Depth of body $2\frac{3}{5}$ in the length, length of head $3\frac{1}{3}$. Upper profile of snout slightly concave. Snout as long as diameter of eye, which is $3\frac{3}{4}$ in length of head,

TEXT-FIG. 6.



Haplochromis taurinus, holotype. Drawn by Miss M. Fasken.

depth of praeorbital $6\frac{1}{2}$, interorbital width $3\frac{1}{3}$. Mouth with somewhat oblique cleft; lower jaw projecting, $\frac{1}{2}$ length of head; maxillary rather strongly exposed, extending to below anterior $\frac{1}{3}$ of eye. Teeth in 3 series, not extending to corners of mouth; outer bicuspid, occasionally with the main cusp obliquely truncate, inner bi- or tricuspid; 30 in outer series of upper jaw. 3 series of scales on cheek. 9 gill-rakers on lower part of anterior arch. Lower pharyngeal bone small, with teeth small, stout, bicuspid, about 8 in a middle series. 32 scales in a longitudinal series, 7 from origin of dorsal to lateral line, 7 between pectoral and pelvic fins. Dorsal XVII 8; last spine $2\frac{3}{5}$ in length of head. Anal III 9; third spine a little shorter than last dorsal. Pectoral nearly as long as head, reaching origin of anal fin. Caudal subtruncate. Caudal peduncle a little longer than deep. Colour silvery; a faint opercular spot and a vertical streak below eye; soft dorsal and caudal spotted.

A single specimen, 164 mm. in total length, from Lake Edward.

A smaller fish, 93 mm. in total length, also from Lake Edward, is included in this species. It is a female, with the lower jaw thrust forward and the branchiostegal membrane spread, owing to the presence of eggs in the mouth. Differences from the type, some of which are related to the smaller size, are:— diameter of eye $3\frac{1}{2}$ in length of head, interorbital width $3\frac{3}{4}$, length of lower jaw $2\frac{1}{5}$; teeth in 2 series, 25 in outer series of upper jaw; lower pharyngeal with 6 or 7 teeth in a middle series; 8 gill-rakers on lower part of anterior arch, the two lowest rudimentary; dorsal XV 9; anal III 8; caudal peduncle $1\frac{3}{5}$ as long as deep.

17. Haplochromis schubotzi Boulenger, 1914.

Boulenger, 1915, p. 288, fig. 196.
Haplochromis angustifrons (part.), Boulenger, t.c. p. 292.
Pelmatochromis spekii (part.) Boulenger, t.c. p. 416.
Haplochromis schubotzi (part.) Regan, 1921. p. 634.

Depth of body $2\frac{1}{2}$ to 3 in the length, length of head $2\frac{3}{4}$ to 3. Diameter of eye $3\frac{1}{2}$ to 4 in length of head, length of snout 3 to $3\frac{1}{2}$, depth of praeorbital $4\frac{1}{2}$ to $5\frac{1}{2}$, interorbital width 4 to $4\frac{1}{2}$. Jaws equal, or lower very slightly projecting; lower $2\frac{1}{4}$ to $2\frac{2}{5}$ in length of head; maxillary reaching vertical from anterior edge of eye, or nearly. Teeth in 3 to 5 series, 46 to 66 in outer series of upper jaw; outer teeth conical or with a small lateral cusp, inner simple or feebly tricuspid. 3 or 4 series of scales on the cheek. 7 or 8 gill-rakers on lower part of anterior arch. Lower pharyngeal small, with dentigerous area narrow in front and with teeth small, bicuspid, occasionally a few with crowns worn down. 30 to 32 scales in a longitudinal series, 4 to 6 from origin of dorsal to lateral line, 6 to 8 between pectoral and pelvic fins. Dorsal XV–XVI 8–10; last spine $2\frac{1}{3}$ to $2\frac{3}{4}$ in length of head. Anal III 8–9, third spine $2\frac{2}{5}$ to 3 in length of head. Pectoral $\frac{3}{4}$ to as long as head, reaching origin of anal. Caudal truncate or slightly emarginate. Caudal peduncle $1\frac{1}{4}$ to $1\frac{3}{5}$ as long as deep. Colour in females silvery, with or without an opercular spot: male with two dark bars across the snout, one on the occiput and one on the nape, a vertical streak below eye and one behind it, a dark blotch on spinous dorsal, three ringed ocelli on the anal and dark pelvic fins.

Lakes Edward and George.

Described from six specimens, 93 to 209 mm. in total length, namely:—

One of the types, 139 mm., coll. Schubotz.

One of the types of *H. angustifrons* 93 mm., coll. Schubotz.

A specimen named *H. spekii,* 108 mm., coll. Schubotz.

A specimen from Lake Edward, 209 mm., coll. Worthington.

Two specimens from Lake George, 107 and 110 mm., coll. Worthington.

Five younger fishes, 52 to 80 mm., from Lake George (coll. Worthington) are also included in this species. Diameter of eye equal to length of snout

or nearly (less in the 52 mm. specimen), $3\frac{1}{4}$ to $3\frac{1}{2}$ in length of head, depth of praeorbital $5\frac{3}{5}$ to $6\frac{1}{2}$, interorbital width $4\frac{1}{2}$ to 5. Caudal peduncle $1\frac{1}{3}$ to $1\frac{1}{2}$ as long as deep. Outer teeth bicuspid. In one specimen there are only XIII dorsal spines.

These are distinguished from young specimens of *H. angustifrons* by the longer snout and somewhat more oblique mouth.

18. HAPLOCHROMIS DOLOROSUS, sp. n.

Depth of body $2\frac{4}{5}$ in the length, of head $2\frac{6}{7}$. Upper profile of snout nearly straight. Length of snout 3 in length of head, diameter of eye $4\frac{1}{3}$, depth of praeorbital $5\frac{1}{2}$, interorbital width nearly 4. Mouth with oblique cleft; lower jaw $\frac{1}{2}$ length of head, slightly projecting; maxillary ending below anterior $\frac{1}{3}$ of eye. Teeth in 3 series, outer conical, inner very small, tricuspid; 50 in outer series of upper jaw. 4 series of scales on cheek. 8 gill-rakers on lower part of anterior arch. Lower pharyngeal with triangular dentigerous area, with teeth of the two middle series enlarged and rather blunt, the rest compressed and bicuspid. 31 scales in a longitudinal series, 6 from origin of dorsal to lateral line, 9 between pectoral and pelvic fins. Dorsal XV 9; last spine $2\frac{1}{2}$ in length of head. Anal III 8; third spine $\frac{1}{3}$ length of head. Pectoral $\frac{5}{7}$ length of head, reaching vent. Caudal subtruncate. Caudal peduncle $1\frac{1}{4}$ as long as deep. Colour dark grey; a vertical stripe below eye, and a horizontal dark bar from eye to opercular spot; a dark stripe along upper lateral line, with three dark patches below it, two patches on lower lateral line; pelvic fins dark; soft dorsal and caudal fins spotted; anal with 3 ocelli.

A single specimen, 120 mm. in total length, from the River Chambura, flowing into Kazinga channel (Station 512).

This is near *H. serranus* of Lake Victoria, but is deeper, with a shorter head and snout, and wider interorbital region.

19. HAPLOCHROMIS SQUAMIPINNIS Regan.

Regan, 1921, p. 636.

Depth of body $2\frac{3}{5}$ to 3 in the length, length of head $2\frac{1}{2}$ to 3. Upper profile straight or slightly concave. Length of snout $2\frac{1}{2}$ to 3 in length of head, diameter of eye 4 to 5, depth of praeorbital $4\frac{3}{4}$ to $5\frac{3}{4}$, interorbital width 4 to $4\frac{3}{5}$. Mouth with oblique cleft; lower jaw, from a little more than $\frac{1}{2}$ to $\frac{3}{5}$ length of head, projecting, with well-marked chin; maxillary extending to vertical from anterior edge of eye. Teeth conical, in 3 or 4 series; 50 to 64 in outer series of upper jaw. 4 or 5 series of scales on the cheek. 8 to 10 gill-rakers on lower part of anterior arch. Lower pharyngeal teeth small, slender, bicuspid, 9 to 11 in a middle series. 31 to 33 scales in a longitudinal series, 5 to 7 between origin of dorsal and lateral line, 5 or 6 between pectoral and pelvic fins. Dorsal XIV–XVI 9–10; last spine $2\frac{1}{6}$ to 3 in length of head. Anal III 9–10; third spine $2\frac{1}{2}$ to $3\frac{2}{3}$ in length of head. Series of small scales at the bases of the rays near the junction of spinous and soft-rayed parts

of dorsal and anal fins. Pectoral $\frac{4}{5}$ to as long as head, reaching level of some part of spinous anal fin. Caudal subtruncate or truncate. Caudal peduncle from a little longer to $1\frac{1}{3}$ as long as deep. Colour silvery, darker above; an opercular spot; dorsal and anal sometimes dusky near the edge; males with dark pelvics and with 2 or 3 ocelli on the anal.

Lakes Edward and George.

Described from the type, 170 mm. (Schubotz), and from 16 specimens, 126 to 233 mm. in total length (Worthington), from stations 501, 504, 531, and 540 in Lake Edward, and station 620 in Lake George. The single Lake George specimen has a somewhat weaker lower jaw.

Twenty-eight young specimens, 82 to 124 mm. in total length, were taken in Lakes Edward and George (stations 511, 540, 573, 613, 618, and 657). They differ from the adults in certain junvenile characters, namely:—Length of snout $2\frac{3}{4}$ to a little more than 3 in length of head, diameter of eye $3\frac{3}{4}$ to $4\frac{1}{3}$, depth of praeorbital $5\frac{2}{3}$ to 7, interorbital width 4 to 5; length of lower jaw $\frac{1}{2}$ length of head or a little less; inner teeth occasionally tricuspid; 32 to 50 outer teeth in upper jaw; cheek occasionally with only 3 series of scales; last dorsal spine $\frac{1}{2}$ to $\frac{3}{4}$ length of head; third anal spine also relatively longer than in adult; scales at bases of fin-rays few, occasionally confined to anal fin; a dark stripe sometimes present from base of caudal to middle of body, or even as far as the opercular spot.

20. Haplochromis mentatus Regan.

Regan, 1925, p. 188, pl. x.

This fish is very similar to the young of *Haplochromis squamipinnis*, but until the type can be re-examined it is judged better not to include it in that species. No specimens in the new collection have been referred to it.

21. Haplochromis guiarti (Pellegrin).

Tilapia guiarti Pellegrin, 1904, p. 186, and 1905, p. 184, pl. xvi, fig. 1.
Haplochromis guiarti Regan, 1922 (*a*), p. 174.

In the collection of the British Museum (Natural History) there is a large number of fishes from Lakes Victoria and Kioga assigned to this species. From these it would appear that the species shows a considerable range of variation, especially in the size of the mouth, the amount of projection of the lower jaw, and the length of the snout. The Lake Edward specimens resemble the longer-snouted forms of Lake Victoria. A description of them follows.

Depth of body $2\frac{3}{5}$ to $3\frac{1}{3}$ in the length, length of head $2\frac{3}{5}$ to 3. Upper profile straight. Length of snout $2\frac{2}{3}$ to 3 in length of head, diameter of eye 4 to 5, depth of praeorbital 5 to 6, interorbital width $3\frac{4}{5}$ to $4\frac{4}{5}$. Mouth with somewhat oblique cleft; lower jaw from a little less than 2 to $2\frac{1}{4}$ in length of head, more or less projecting; maxillary reaching vertical from anterior edge of eye

or nearly. Teeth conical, in 2 to 4 series, 30 to 60 in outer series of upper jaw. 3 to 5 series of scales on the cheek. 8 or 9 gill-rakers on lower part of anterior arch. Lower pharyngeal with small bicuspid teeth. 32 to 35 scales in a longitudinal series, 5 to 7 from origin of dorsal to lateral line, 6 to 8 between pectoral and pelvic fins. Dorsal XIV–XVI 9–11; last spine $2\frac{2}{5}$ to 3 in length of head. Anal III 8–9; third spine $2\frac{2}{3}$ to $3\frac{1}{2}$ in length of head. Pectoral $\frac{3}{5}$ to $\frac{4}{5}$ length of head, reaching vent or origin of anal. Caudal truncate, or with rounded corners and a slight emargination. Caudal peduncle $1\frac{1}{6}$ to $1\frac{1}{2}$ as long as deep. Colour silvery, darker in adult male; an opercular spot; often two dark longitudinal stripes, one from opercular spot to base of caudal, the other above upper lateral line; sometimes traces of six vertical stripes; dorsal and upper part of caudal usually spotted. Males with dark pelvics and with 2 to 5 ocelli on the anal fin.

Described from seventeen specimens, 104 to 172 mm. in total length (Worthington), from Lake Edward (stations 543, 553, 573, and others of which the numbers are lost).

Three young fishes, 72 to 80 mm. in total length, are also referred to this species. They are from Lake George (stations 613 and 618) and the East shore of Lake Edward. In them the outer teeth are bicuspid, the inner tricuspid.

VIII. SCHUBOTZIA Boulenger, 1914.

Near *Haplochromis*, from which it differs in having the outer teeth close-set, enlarged, with strongly incurved flattened crowns with rounded edges, followed by two series of minute tricuspid teeth.

SCHUBOTZIA EDUARDIANA Boulenger.

Boulenger, 1914, p. 258, pl. vii, figs. 2 & 3, and 1915, p. 500, fig. 347.

Lake Edward.

This species is known only from the types, which measure up to 95 mm. in total length.

REFERENCES.

BEADLE, L. C. 1932. Scientific Results of the Cambridge Expedition to the East African Lakes, 1930–1.—4. The Waters of some East African Lakes in relation to their Fauna and Flora. J. Linn. Soc. London, xxxviii, p. 157–211.

BOULENGER, G. A. 1905. The Distribution of African Fresh-water Fishes. Rep. Brit. Ass. Adv. Sci. 1905. Address to Section D, pp. 412–32.

——. 1911. On a Third Collection of Fishes made by Dr. E. Bayon in Uganda, 1909–1910. Ann. Mus. Genova, (3) v, pp. 64–78, pls. i–iii.

——. 1914. Fam. Cichlidae in Schubotz, Wiss. Ergebn. Deutsch. Z.-Afr. Exped. v, Zool. iii, Fische, pp. 253–59.

——. 1915. Catalogue of the Fresh-water Fishes of Africa [Brit. Mus. (Nat. Hist.)], iii.

GRAHAM, M. 1928. *Tilapia esculenta*, a new Species of Cichlid Fish from the Victoria Nyanza. Ann. Mag. Nat. Hist. (10) ii, pp. 209–13.

HILGENDORF, F. 1903. Ein Süsswasserfisch aus der Nähe von Alexandria, *Paratilapia multicolor*. SitzBer. Ges. Naturf. Fr. Berlin, pp. 429–32.

PELLEGRIN, J. 1903. Contribution à l'étude anatomique, biologique et taxonomique de la famille des Cichlidés. Mém. Soc. Zool. Fr. xvi, pp. 41–400.

——. 1904. Diagnoses préliminaires de poissons nouveaux du lac Victoria recueillis par Mr. Alluaud. Bull. Soc. Zool. Fr. xxix, 1904, pp. 184–6.

——. 1905. Mission scientifique de Ch. Alluaud en Afrique orientale.—II. Systématique. Mém. Soc. Zool. Fr. xvii, pp. 174–85.

——. 1910. Mission scientifique de Ch. Alluaud en Afrique orientale (1908–9). Poissons. Mém. Soc. Zool. Fr. xxii, pp. 281–98.

REGAN, C. TATE. 1921. The Cichlid Fishes of Lakes Albert, Edward, and Kivu. Ann. Mag. Nat. Hist. (9) viii, pp. 632–9.

——. 1922 (*a*). The Cichlid Fishes of Lake Victoria. Proc. Zool. Soc. London, 1922, pp. 157–91.

——. 1922 (*b*). The Classification of the Family Cichlidae.—II. On African and Syrian Cichlidae not restricted to the Great Lakes. Ann. Mag. Nat. Hist. (9) x, pp. 249–64.

——. 1925. Three new Cichlid Fishes of the Genus *Haplochromis*, from Lake Edward, Central Africa. Occ. Pap. Boston Soc. Nat. Hist. v, pp. 187–8.

Scientific results of the Cambridge Expedition to the East African Lakes, 1930–1.—12. Aquatic Heteroptera. By Dr. TADEUSZ JACZEWSKI (Polish Museum of Zoology, Warsaw). (Communicated by Dr. E. B. WORTHINGTON, F.L.S.)

(With 1 Text-figure)

[Read 2 February 1933]

THE aquatic Heteroptera collected by the Cambridge Expedition to the East African Lakes, which have been submitted to me for examination, comprise some 400 specimens. Twenty-two species are represented, one of which, from Lake Rudolf, is new to science. In addition, the collection is of interest in extending the distribution of several other species which were little known before. The station-numbers refer to the Expedition's published station-list (Worthington, 1932).

Family MESOVELIIDAE.

MESOVELIA VITTIGERA Horv.

Lake Baringo, stn. 132, 1 ♀ macropterous.
Lake Bunyoni, stn. 715, 1 ♀ brachypterous.

Family HYDROMETRIDAE.

HYDROMETRA sp.

Lake Edward, stn. 516 A, 1 ♀, teneral, cannot be identified with certainty.

Family NOTONECTIDAE.

ENITHARES SOBRIA (Stål).

Lake Baringo, stn. 132, 1 ♂.

ANISOPS (ANISOPS) SARDEA H. S.

Lake Rudolf, stns. 213, 2 ad., 235, 1 ad., 280, 8 ad.
Lake Naivasha, stn. 34, 1 ad.
Lake Baringo, stns. 112, 4 ad., 132, 2 ad.
Lake Edward, stn. 542, 1 ad.
Lake George, stn. 603, 1 ad., 12 larvae.

ANISOPS (ANISOPS) WORTHINGTONI, sp. n. (Text-fig. 1.)

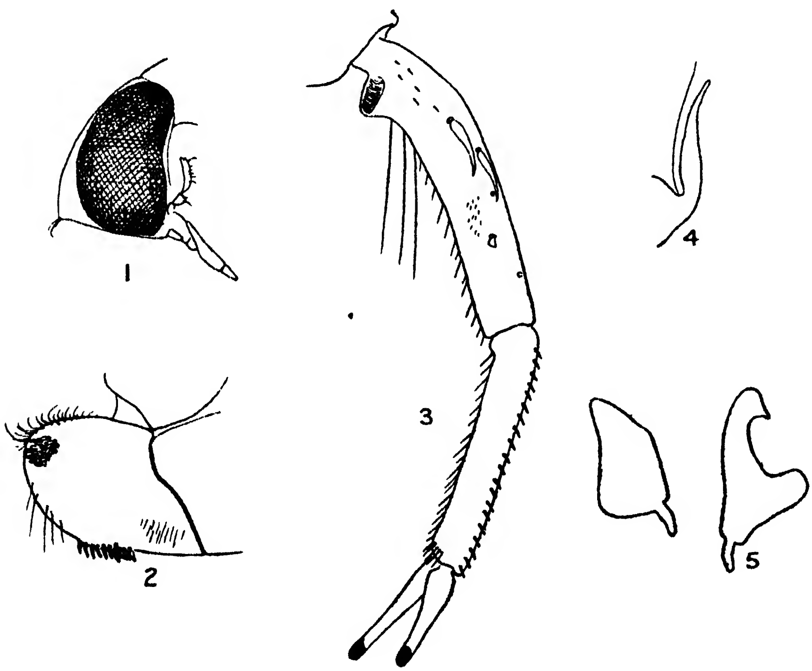
Lake Rudolf, stn. 280, 1 ♂, 1 ♀.

Length 6·5 mm. Yellowish white, fairly slender.

Head of the ♂ produced in front into a distinct prominence, resembling that of the Australasian *A. fieberi* Kirk. (Hale, 1923), much smaller, however,

than the cephalic prominence in *A. sardea* H. S. At its apex some elongated dark hairs are inserted. Face of the ♂ flattened. Head of ♀ simple, vertex forming a very slight, but easily discernible convex prominence between the eyes, when seen from above. Vertex in both sexes a little over three times as wide as the synthlipsis. Rostral prongs of the ♂ moderately divergent.

Trochanter of the front legs of the ♂ armed with two groups of short, slightly curved pegs, one at the basal prominence, the other at the lower margin. Tibial prong with about fifteen lamellae. Outer margin of the tibia with two



Anisops worthingtoni, sp. n. ♂.

1. Side view of head, ×16. 2. Trochanter of front leg, ×52. 3. Front tibia and tarsus, ×52. 4. Spine of 7th abdominal segment, ×60. 5. Parameres, ×60.

thickened spines and a short peg inserted more distally. Inner margin with three long basal bristles and a number of shorter ones. Tarsal joint with a continuous row of short spines along its outer margin. Tibia $1\frac{1}{4}$ times as long as the tarsus, which is twice as long as the longer claw.

Sinistral spine of the seventh abdominal segment of the ♂ thickened in its basal portion, curved and tapering towards the apex. Parameres as shown in the text-figure.

This species differs at once from all the other African representatives of the

genus by the structure of the head and of the front legs in the ♂♂, the ♀♀ may be recognized by their slightly prominent vertex.

I have pleasure in dedicating this species to Dr. E. B. Worthington, its discoverer.

ANISOPS (ANISOPS) PELLUCENS Gerst.

Lake Bunyoni, stn. 702, 1 ♀.

ANISOPS (ANISOPS) BALCIS Hutch.

Lake Baringo, stns. 112, 21 ad., 10 larvae, 114, 1 ad.
Lake Rudolf, stns. 213, 19 ad., 240, 1 ad., 280, 3 ad.
Lake Kaianda, north end of Lake Edward, 1 ad.
Lake Nakavali, stn. 803, 1 ad., numerous larvae.

ANISOPS (ANISOPS) AMARYLLIS Hutch.

Lake Naivasha, stns. 16, 8 ad., 23, 27 ad., 27, 2 ad.
Naivasha, rainpool above Pickfords, 2 ad.

ANISOPS (ANISOPS) EROS Hutch. ?

Lake Naivasha, stn. 27, 8 ad., 18 larvae.

These specimens fit very well Hutchinson's description of the species, save that the tibial combs in the ♂♂ are almost identical with those of the preceding species.

ANISOPS (MICRANISOPS) APICALIS (Stål).

Lake Baringo, stn. 114, 3 ad.
Lake Edward, stn. 507, 5 ad., 1 larva.

NYCHIA LIMPIDA Stål.

Lake George, stn. 606, 6 ad., 2 larvae, one of the adults belongs to the form *sappho* Kirk.

Family PLEIDAE.

PLEA PULLULA Stål.

Lake Naivasha, stn. 31, 1 ad.
Lake Baringo, stns. 112, 1 ad., 114, 6 ad., 1 larva, 132, 12 ad.
Lake George, stns. 603, 3 ad., 626, 4 ad.
Lake Bunyoni, stn. 724, 2 ad., 1 larva.
Lake Nakavali, stn. 812, 4 ad.
Lake Kachira, stn. 827, 1 ad.
Most specimens are very dark in colour.

PLEA PICCANINA Hutch.

Lake Baringo, stn. 132, 1 ad.

Family HELOTREPHIDAE.

HELOTREPHES HUNGERFORDI Esaki & China.

Lake Bunyoni, stn. 702, 1 ♀.

This species was known hitherto only from one locality in French Equatorial Africa.

Family CORIXIDAE.

AGRAPTOCORIXA DAKARICA Jacz.

Lake George, stn. 603, 1 ♂, 3 larvae.

SIGARA SJÖSTEDTI (Kirk.).

Lake Naivasha, stns. 16, 2 ♂♂, 10 ♀♀, 27, 2 ♀♀.

SIGARA HIEROGLYPHICA KILIMANDJARONIS (Kirk.).

Lake Naivasha, stns. 32, 20 ♂♂, 14 ♀♀, 3 larvae, 34, 1 ♀.

MICRONECTA RAS Hutch.

Lake Naivasha, stns. 32, 94 ad., 12 larvae, 34, 87 ad., 3 larvae.

Lake Rudolf, stns. 211 B, 12 ad., 32 larvae, 213, 12 ad., 40 larvae, 220, 17 ad., 1 larva, 240, 58 ad., 3 larvae.

Lake Edward, stn. 542, 1 ad.

Lake Kaianda, north end of Lake Edward, 2 ad.

Lake George, stns. 606, 3 ad., 626, 1 ad.

I am not quite sure whether this species and *M. scutellaris* (Stål) are really distinct specifically.

MICRONECTA COMPAR Horv.

Lake Baringo, stns. 114, 1 ad., 132, 7 ad.

MICRONECTA QUEWALEPELE Hutch.

Lake Edward, stn. 542, 12 ad.

MICRONECTA YOUNGIANA Hutch. ?

Lake Nakavali, stn. 812, 1 ♀.

The identification of this specimen is somewhat doubtful, as no males were found in the material submitted.

MICRONECTA PICCANIN Hutch.

Lake Naivasha, stn. 23, 1 ad.

Lake Bunyoni, stn. 724, 21 ad.

Lake Nakavali, stn. 812, 1 ad.

G. L. R. Hancock, 1931, Lake Kigere, Fort Portal, 8 ad.

REFERENCES.

HALE, H. M. 1923. Rec. S. Austr. Mus. Adelaide, ii. no. 3, p. 401, fig. 363.

WORTHINGTON, E. B. 1932. Scientific Results of the Cambridge Expedition to the East African Lakes, 1930–1.—1. General Introduction and Station List. Journ. Linn. Soc., Zool. vol. xxxviii, no. 258, p. 99.

Scientific results of the Cambridge Expedition to the East African Lakes, 1930–1.—13. Adaptation to aerial respiration in *Alma emini* Mich., an Oligochaet from East African swamps. By L. C. BEADLE. (Communicated by Dr. E. B. WORTHINGTON, F.L.S.)

(With 2 Text-figures)

[Read 2 March 1933]

THE possession of an external longitudinal groove on the dorsal surface of the hind end is common to many oligochaets of the family Glossoscolecidae. From observations on the living animals, and from a study of the histological structure of the groove epithelium it was concluded that *Drilocrius* sp., a Glossoscolecid abundant in the swamps of the Paraguayan Chaco of South America, was able to employ this groove as an aerial respiratory organ (Carter & Beadle, 1931). *Drilocrius* was found living in the wet mud at the edge of the swamp. Analyses showed that for long periods of time the shallow water at the edge contained no measurable amount of oxygen except within an inch of the surface. It may therefore reasonably be concluded that the water in the mud was devoid of oxygen (Carter & Beadle, 1930). That *Drilocrius* was found only at the swamp edge and in mud covered by not more than about ½ inch of water indicates that it is confined to a position from which it has access to the air.

Alma emini Mich.* is a common inhabitant of the swamps of East Africa. Both *Drilocrius* and *Alma* are members of the same subfamily (Microchaetinae). In size, in general appearance, and in the possession of a dorsal groove at the hind end these two forms are very similar.

During the Cambridge Expedition to the East African Lakes (1930–1) *Alma emini* was found in the mud at the edge, and in the thick masses of decaying vegetation floating on the surface of Papyrus swamps near Kampala, and in the Kazinga Channel in Uganda. The waters of these swamps were characterized by a scarcity of dissolved oxygen (Beadle, 1932). This worm was also found in sand at the edge of a fast-flowing stream rising from the western slopes of the Ruwenzori Mountains in the Belgian Congo. It is, therefore, not confined to waters of low oxygen content.

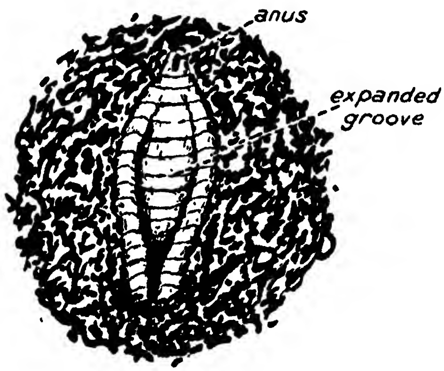
Specimens collected from the Kazinga Channel swamps at Katunguru in May 1931 towards the end of the wet season had well-developed paired copulatory appendages attached to segment xx. Two months later (July 1931), after a period of drier weather, none with appendages could be found.

* Identified by the late Lt.-Col. J. Stephenson, C.I.E., F.R.S.

Observation of the surface of the mud during the day established the fact that the worm protruded into the air about ½ cm. of its hind end. The groove appeared to be nearly, if not quite, closed at the proximal end of the exposed portion (where it protruded from the mud), but was splayed out at the distal end to form an incomplete funnel (text-fig. 1). The floor of the groove at this end could now be observed, the underlying blood-vessels were clearly visible, and muscular undulations similar to those on the foot of a gastropod mollusc could be seen passing over it. A worm would remain exposed in this way for some minutes, but on the slightest disturbance the hind end was rapidly withdrawn.

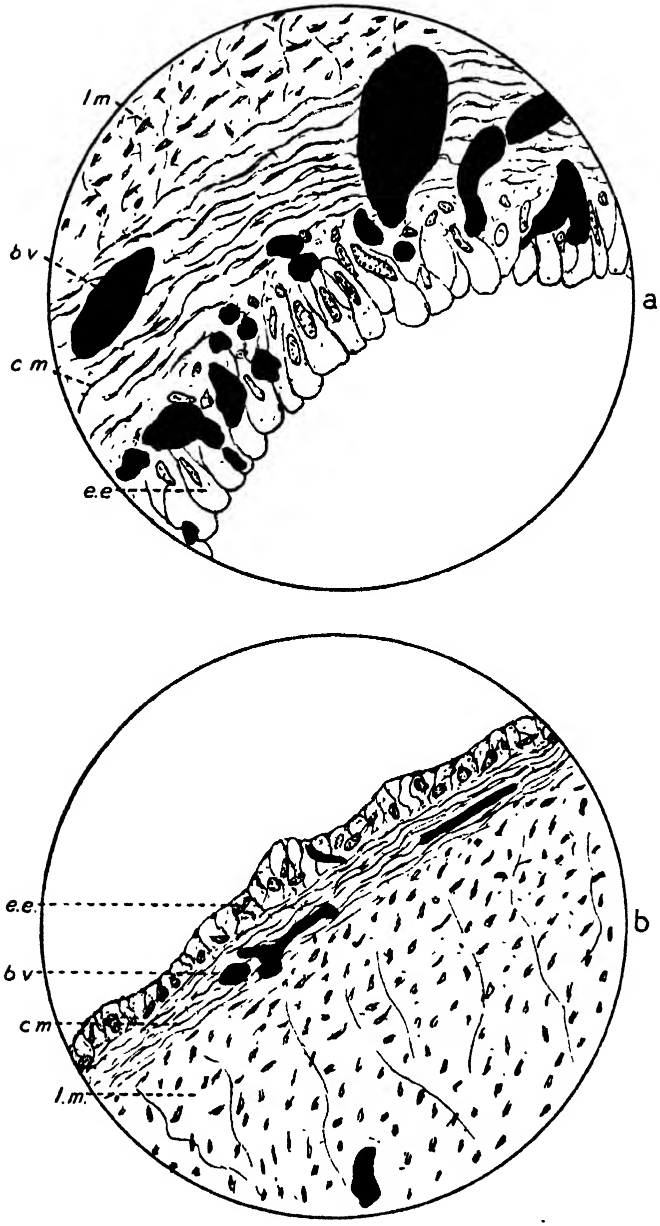
Animals placed in about ¼ in. of water in a Petri dish were seen to expose as much as ½ in. of the groove at the surface. In this case the exposed portion of the groove was opened out so as to present an almost flat surface to the air.

TEXT-FIG. 1.



Specimens were fixed in Bouin's fixative and transverse sections (5 μ) of the grooved region were cut and double-stained with haematoxylin (Carrazzi's formula) and eosin. The histological structure is similar to that of *Drilocrius* in that the ectodermal epithelium lining the groove is formed of deep columnar cells with large (in this case elongated) nuclei (text-fig. 2, *a*). A large number of blood-capillaries penetrate this epithelium, a condition to be expected in a respiratory surface. No other type of cell can be detected in this layer, nor does it appear that there is a granular proximal region to the cytoplasm of the columnar cells such as was found in *Drilocrius* (Carter & Beadle, 1931, p. 384). It was suggested that the columnar cells of *Drilocrius* were glandular and may have secreted mucus over the surface of the groove. But specific mucus stains (muci-carmine, muci-haematin, and carbol-thionin) gave negative results with sections of *Alma*. This may have been due to inappropriate fixation and preservation (Bouin and 70 per cent. alcohol).

TEXT-FIG. 2.



b.v., blood-vessels; *c.m.*, circular muscle; *e.e.*, ectodermal epithelium; *l.m.*, longitudinal muscle.

Both drawn to the same scale ($\frac{1}{12}''$ objective).

The cells of the lateral ectodermal epithelium in the same region of the body are much shallower, the nuclei are smaller and the blood-supply is by comparison scanty (text-fig. 2, *b*). This condition is typical of all the ectoderm, other than that lining the groove.

It is interesting to note that the layer of circular muscle in the mid-dorsal line under the groove is much expanded dorso-ventrally, while the circular muscle-fibres under the rest of the ectoderm are more compact and occupy less space (text-fig. 2). Closure of the groove is, therefore, probably brought about by the operation of the muscles in the mid-dorsal line.

Conclusions.

From the above observations on the living animal in its natural habitat and under experimental conditions, and from a study of histological structure, it is suggested that the dorsal longitudinal groove of *Alma emini* is employed as an organ for aerial respiration. It is commonly found in the mud of East African swamps where there is little or no available dissolved oxygen. This adaptation is of especial interest in that *Drilocrius* sp., another member of the same subfamily (Microchaetinae) inhabiting the swamps of central South America, also possesses a dorsal groove, for which similar evidence has suggested the function of aerial respiration.

References.

Beadle, L. C. The Bionomics of some East African Swamps. Journ. Linn. Soc., Zool. vol. xxxviii, no. 258, p. 135 (1932).

Carter, G. S., & Beadle, L. C. The Fauna of the Swamps of the Paraguayan Chaco in relation to its Environment.

I. The Physico-chemical Nature of the Environment. *Ibid.* vol. xxxvii, no. 251, p. 197 (1930).

III. Respiratory Adaptations in the Oligochaeta. *Ibid.* vol. xxxvii, no. 258, p. 135, (1931).

Scientific results of the Cambridge Expedition to the East African Lakes, 1930–1.—14. Crustacea Macrura (Prawns). By ISABELLA GORDON, D.Sc., Ph.D., British Museum (Nat. Hist.).

(With 7 Text-figures)

[Read 6 April 1933]

INTRODUCTION.

By far the greater number of the Crustacea are fresh-water prawns belonging, for the most part, to the genus *Caridina*. The majority of the specimens were collected in Lake Bunyoni, and these exhibit an unusual amount of variation of the rostrum. With regard to Lake Edward it is almost certain that none of the specimens came from the lake itself*, although *Caridina africana* was found in several affluents at a distance of a mile or less from the lake.

It is an interesting fact that *Caridina* does not occur in Lake Rudolf, where it is replaced by a species of *Palaemon*. In this respect Lake Rudolf differs from Lakes Albert and Victoria. The specimens probably represent a variety or local race of the species *P. niloticus* previously recorded from the Nile (Egypt and the Sudan) and from Lake Chad.

I have to thank Dr. Worthington for submitting the material to me for examination.

CARDINA NILOTICA (Roux).

De Man, J. C., 1908, Rec. Ind. Mus. II, pt. 3, no. 28, pp. 253–8, pl. xx.
Bouvier, E. L., 1925, Encyclopédie Entomologique.—IV. 'Atyidés,' Paris, pp. 143–159.
Gordon, I., 1930, P. Z. S. pp. 33–50.

Most of the specimens belonging to the genus *Caridina* are apparently referable to *C. nilotica*, a species of wide distribution in East Africa, where it has given rise to a considerable number of local forms differing somewhat from each other and from the typical Egyptian form (Gordon, 1930). It is therefore deemed advisable to discuss the material in the present collection under each separate locality. The specimens were studied in much the same way as those from Lakes Albert and Victoria (Gordon, 1930). Wherever possible ovigerous females were measured, and the ratios given in Table I (for the peraeopods) should be compared with those in Table II of the previous paper (Gordon, 1930, pp. 42 & 43). Owing to the extreme variability of the rostrum, especially as regards length, in the material from Lake Bunyoni,

* With the possible exception of the specimen from Kaianda (see p. 352).

the length of the specimens given in this paper is that from postorbital border to tip of telson.

A. Near LAKE EDWARD. (*a*) Stn. 567. From shallow weedy backwater, River Semliki, ¼ mile down stream from L. Edward: 1 ovigerous ♀. (*b*) Kaianda, north end of Lake: 1 ovigerous ♀ *.

Description.—Telson in each specimen of type 1, i.e. similar to that represented in fig. 1 (Gordon, 1930, p. 34).

Peraeopods. In the female from Kaianda peraeopod 1 is similar to that of *C. nilotica* var. *typica* from Egypt, but peraeopod 2 has the fingers rather longer relatively to the palm. Peraeopods 3 and 5 are typical.

In the specimen from Stn. 567 peraeopods 1 and 2 have each considerably longer fingers relatively to the palm, and the former has a somewhat longer and narrower carpus than in var. *typica*. Peraeopod 3 is typical; peraeopod 5 has a slightly narrower dactylus.

Rostrum in both specimens exceeds the antennal scale and is equal to, or slightly longer than, the carapace. Rostral formula: $\frac{3+13+1+2}{15}$ (st. 567) and $\frac{2+14+3}{14}$; proportion of dorsal surface unarmed approximately two-fifths in each case (·38 and ·41 respectively).

Sixth abdominal segment exceeding half, but less than two-thirds, the length of the carapace.

Ova measuring ·59–·64×·36–·40 mm.; a little smaller than in var. *typica*.

Remarks.—According to the key given by de Man (1908, pp. 257–9) these specimens are nearest to *C. nilotica* (i.e. to var. *typica*) and *C. nilotica* var. *natalensis*, but the ova are nearer in size to those of the former. Apart from the differences in the peraeopods already mentioned, these specimens agree with the typical form.

B. LAKE GEORGE. Stn. 617. Swamp at north end of lake: 3 ♂♂, 4 ♀♀ (3 ovigerous), and several young specimens.

Description.—Telson of type 2 (i.e. similar to that represented in fig. 2, Gordon, 1930, p. 134) in ten specimens and of type 1 in the remaining one.

Peraeopods. Peraeopods 1 and 2 have the fingers somewhat longer relatively to the palm than in var. *typica*. Peraeopod 3 agrees with, but peraeopod 5 has the dactylus rather more slender than in the typical form.

Rostrum extending beyond antennal scale; subequal to or slightly longer than the carapace (1·05–1·15 : 1), armed with $\frac{2\text{–}3+13\text{–}16+1}{14\text{–}16}$ teeth; proportion of dorsal surface unarmed ·36–·40.

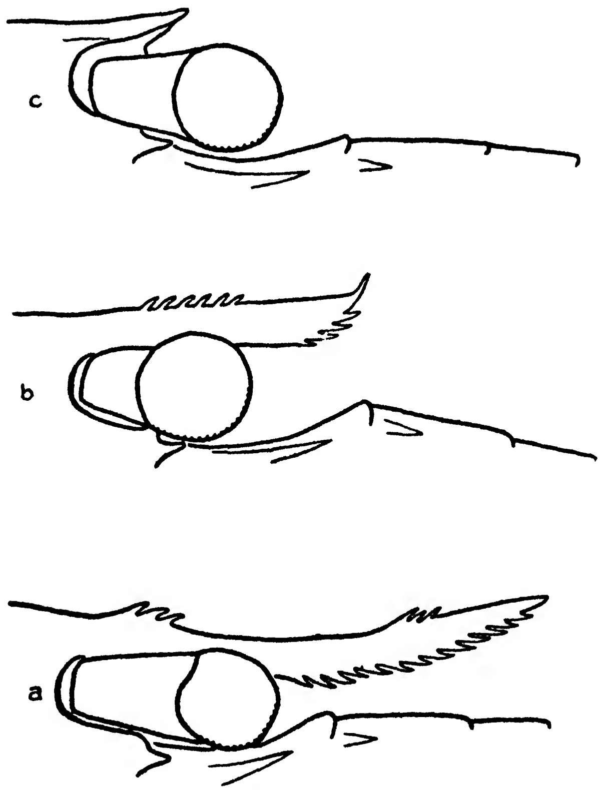
Sixth abdominal segment rather more than half the length of the carapace (·55–·57 : 1).

* [This specimen was collected by Mr. Beadle, and I am not quite certain of the data. It was almost certainly from a lagoon close to the lake shore and actually connected with the lake by a narrow passage. It may conceivably have come from the shore of the main lake.—E. B. W.]

Ova measuring ·84–·88×·52–·56 mm.; somewhat larger than in var. *typica*, almost as large as in *C. nilotica* from Lake Ngami (Gordon, 1930, p. 43; Table II).

Remarks.—Unfortunately the specimens are incomplete, with one or more of the peraeopods missing in the females. According to De Man's key (1908, pp. 257–9) the form falls into division I *cc*, since the number indicating the proportion between length and breadth of the dactylus of peraeopod 5 exceeds

TEXT-FIG. 1.



a–c. Caridina nilotica (Roux) from Lake Bunyoni; rostrum in lateral aspect to illustrate the large range of variation.

4·6 [4·86 (? sex) and 5·23 (♂)]. But it does not agree with de Man's var. *paucipara*, since there are only 48–56 instead of 60–74 spines on the dactylus of peraeopod 5 and the ova are of smaller size.

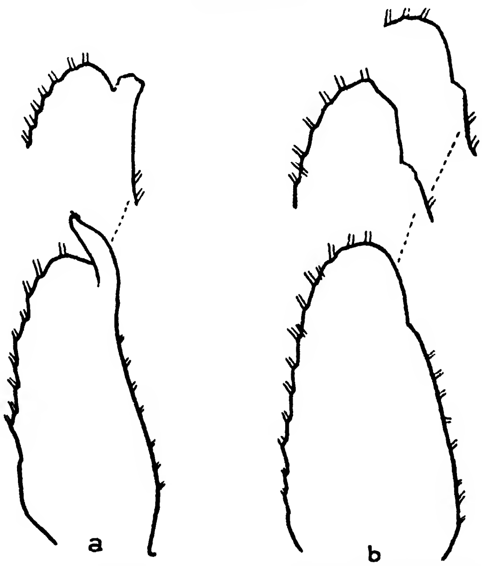
The specimens are too few to afford much idea of the range of variation in the peraeopods. This form is near to the two specimens collected from Lake Edward; the dactylus of peraeopod 5, however, appears to be more slender than in the latter.

C. LAKE BUNYONI. (*a*) Stn. 705. Bufundi; from weedy area bordering the lake: numerous specimens both adult and young. (*b*) Stn. 707, A & B. Bufundi; from weedy area bordering the lake: numerous specimens both adult and young.

Description.—1. *Female.*

Telson. Of the 260 specimens examined, 23, 68, and 5 per cent. belong to the types represented in figs. 1, 2, and 3 respectively (Gordon, 1930, pp. 34, 35, and 37; Table I); the remainder are either incomplete or somewhat abnormal. In this respect, therefore, the specimens agree with those from Egypt and Lakes Albert and Victoria.

TEXT-FIG. 2.



Endopod of pleopod 1 of ♂ of *Caridina nilotica* (Roux).
a, from Egypt (var. *typica*); *b*, from Lake Bunyoni. × 100. The setae are not drawn in, but their position is indicated by short double lines.

Peraeopods. Fourteen ovigerous females were measured. Peraeopods 1 and 3 agree for the most part with *C. nilotica* var. *typica.* Peraeopod 2 has the fingers longer relatively to the palm in eight specimens. Peraeopod 5 in the majority of the specimens (10) has the propodus shorter relatively to the dactylus; the latter segment is also more slender in seven specimens.

Rostrum. These specimens are remarkable for the extreme variability of the rostrum (text-fig. 1). In many instances it extends to the distal end of the antennular peduncle, or even to the tip of the antennal scale (i.e. varies from two-thirds of, to equality with, the carapace-length). Moreover, the number of teeth on the dorsal and ventral margin varies greatly as the following formulae show :—

$$\frac{2+16+1}{12};\quad \frac{0+12+1+1}{17};\quad \frac{0+10+0}{15};\quad \frac{0+6+0}{12};\quad \frac{1+7+1+1}{0};\quad \frac{0+5+0}{9};\quad \frac{0+5+0}{0}.$$

There is a marked tendency towards reduction of the dorsal series, so that, in the specimens examined, it was most usual for the ventral to exceed the dorsal number of teeth (in 16 out of 22 specimens; see text-fig. 1, *a*). Sometimes the ventral series is greatly reduced or absent.

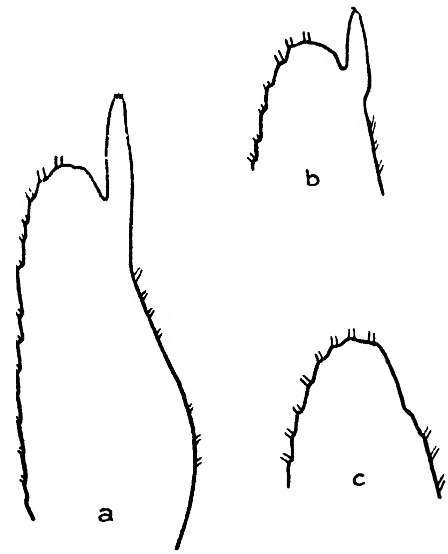
In many specimens the rostrum does not reach much beyond the cornea of the eye (i.e. $=\frac{1}{3}-\frac{1}{4}$ of the carapace-length). Although again subject to much variation, the type represented in text-fig. 1, *b*, with a few subterminal teeth on the ventral margin, is most common.

The rostrum is even more reduced in a large number of specimens until, in extreme cases, it does not exceed one-tenth of the carapace-length (text-fig. 1, *c*). These three groups are united by many intermediate forms.

Sixth abdominal segment varies from ·56–·63 of the carapace-length.

Ova ·76 × ·48 mm.

TEXT-FIG. 3.



a–c. Caridina nilotica (Roux), from Lake George; endopod of pleopod 1 of ♂. × 100.

2. *Male.*

The endopod of the first pleopod of *C. nilotica* var. *typica* is represented in text-fig. 2, *a* (l. = 14 and 17·4 mm. respectively, exclusive of the rostrum). No trace of the elongated subapical process is apparent in three males from Lake Bunyoni (text-fig. 2, *b*; l. = 17·76, 17·6, and 16·4 mm. respectively, exclusive of the rostrum). This was thought to indicate a difference between the specimens from these two localities, until the process in question was found to be absent in one out of three large males from Lake George (text-fig. 3, *c*: *a–c*, l. = 18·56, 18·56, and 19·6 mm. respectively, rostrum excluded). It may be that this sexual process is only present for a short time during the breeding-season, but no exact data on this point are available.

TABLE I.

Locality.	Peraeopods.				Size of ova (in mm.).
	1.	2.	3.	5.	
A. *Caridina nilotica.*					
1. Near Lake Edward (2)* ..	*a*, 3·00 and 2·67 *b*, 1·50 ,, 1·20 c, 0·93 ,, 1·25	*a*, 5·81 and 5·04 *b*, 1·48 ,, 1·40 c, 0·79 ,, 0·84	*x*, 4·21 and 4·65 *y*, 3·80 ,, 3·33 *z*, 9 ,, 9	*x*, 3·39 and 3·77 *y*, 4·67 ,, 4·42 *z*, 46 ,, 44	l, 0·59–0·64 b, 0·34–0·40
2. Near Lake George (4) ...	*a*, 2·4 –2·86 *b*, 1·30–1·55 *c*, 1·15–1·12	*a*, 5·38–5·79 *b*, 1·30–1·62 c, 0·70–0·81	*x*, 4·34– 5·00 *y*. 3·50– 3·90 *z*, 10 –12	*x*, 3·3 *y*, 4·86 *z*, 48	l, 0·84–0·88 b, 0·52–0·56
3. Lake Bunyoni (14)	*a*, 1·32–1·96 *b*, 0·97–1·30 *c*, 1·29–1·57	*a*, 3·31–4·00 *b*, 1·10–1·73 c, 0·88–1·16	*x*, 3·78– 4·45 *y*, 3·33– 4·17 *z*, 8 –12	*x*, 2·58– 3·33 *y*, 4·11– 5·30 *z*, 38 –50	l, 0·76 b, 0·48
B. *Caridina africana.*					
Near Lake Edward (5)	*a*, 2·1 –2·43 *b*, 1·2 –1·36 c, 1·13–1·31	*a*, 4·29–5·28 *b*, 1·25–2·13 c, 0·77–0·83	*x*, 4·65– 5·76 *y*, 2·78– 3·57 *z*, 7 – 9	*x*, 2·5 – 3·07 *y*, 5·42– 5·88 *z*, 58 –76	l, 1·20–1·24 b, 0·75–0·80

a = length ÷ breadth of carpus.
b = length of fingers ÷ length of palm.
c = length of chela ÷ length of carpus.
x = length of propodus ÷ length of dactylus.
y = length ÷ breadth of dactylus.
z = number of dactylar spines (terminal claw included).

* Number of specimens measured.

Remarks.—The specimens from Lake Bunyoni are more variable than any other African material of *C. nilotica* examined. In this respect they recall *C. brevirostris* from the Seychelles (Bouvier, 1913, Trans. Linn. Soc., Zool. xv, pt. 4, no. 28, p. 448), where, however, the chelipeds as well as the rostrum vary considerably. Apart from the rostrum, the Lake Bunyoni specimens are quite near to *C. nilotica* var. *typica*. The differences exhibited by peraeopods 2 and 5 are somewhat similar to, though less pronounced than, those found in the prawns from Butiaba, Lake Albert, and from the open waters of Lakes Albert and Victoria (Gordon, 1930, p. 42; Table II).

CARIDINA AFRICANA Kingsley.

Bouvier, E. L., 1925, 'Atyidés,' Encyclopédie Entomologique, p. 212.

Localities.—

1. Near LAKE EDWARD :—

(*a*) Stn. 512, 5. River Chambura, which flows into the Kazinga Channel near Katunguru—from swampy shore about a mile from mouth of river : 7 specimens.

(*b*) Stn. 522, 1. River Niamweru, which flows into east shore of Lake Edward—from swampy shore about a mile from mouth of river : 6 specimens.

(*c*) Stn. 522, 4. River Luampuno, east shore of Lake Edward—from swampy shore about a mile from mouth of river : 6 specimens.

(*d*) Stn. 542, 2. Swampy back-water of River Niamweru, actually at river's mouth into Lake Edward : 6 specimens.

'Thus all specimens of this species came from more or less swampy conditions, not actually from the lake itself, but from the lower reaches of the affluent rivers close to the lake.'—E. B. W.

(*e*) Small river near Malabunde, Belgian Congo, near Lake Edward : 4 specimens.

2. B. 36. Probably from KAMPALA, collected by G. L. R. Hancock, Esq. : 1 ♀.

3. ARUA, WEST NILE, collected by G. L. R. Hancock, Esq. : 6 specimens.

Remarks.—*E. africana* can at once be distinguished from *C. nilotica* by the *telson*, which possesses a group of 7–11 long slender setose spines between the pair of strong lateral ones (Gordon, 1930, P. Z. S. p. 38, cf. fig. 6 with figs. 1–4).

The *rostrum*, although subequal to the antennal scale, is always shorter than the carapace (·67–·84 : 1). Rostral formula $\frac{3\text{–}4+11\text{–}18}{5\text{–}10}$; thus there are always at least twice as many dorsal as ventral teeth ; the unarmed portion of the dorsal surface is usually one-fifth or less (Gordon, 1930, P. Z. S. p. 49, fig. 13, *a*).

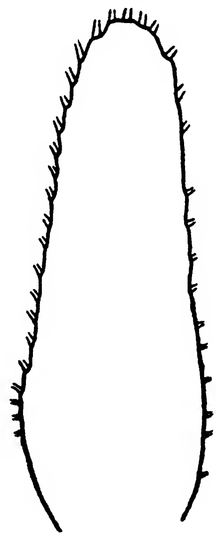
The specimens may reach a length of 27–28 mm., exclusive of the rostrum.

The ova measure 1·20–1·24×·75–·80 mm., i.e. are approximately twice as large as those of *C. nilotica* collected in the vicinity of Lake Edward (·59–·64× ·36–·40 mm.).

According to Bouvier's key to the varieties (1925, p. 213) these specimens are nearest to *C. africana* var. *typica*, since the dactylus of peraeopod 3 is, on an average, one-fifth of the propodus.

The rostral formula is not quite the same as that given by Kingsley and Ortmann for var. *typica* $\left(\frac{10-15}{7-12}\right)$, but agrees with that of a female from River Waki, Lake Albert, referred to var. *typica* by Bouvier (1925, pp. 213–4). The ova are also of similar size to those of the latter specimen.

TEXT-FIG. 4.



Caridina africana Kingsley; endopod of pleopod 1 of ♂ (l.=21 mm.+rostrum).

Peraeopods. The peraeopods differ considerably from those of *C. africana* var. *aegyptiaca* (cotypes, Gordon, 1930, P. Z. S. p. 43; Table II). In peraeopod 1 the fingers are somewhat shorter relatively to the palm in three of the five specimens measured, while, in all cases, the carpus is slightly longer relatively to the chela. In each specimen measured the dactylus of peraeopod 3 is shorter relatively to the propodus, and the dactylus of peraeopod 5 is rather narrower in proportion to its length. The number of spines on the latter exceeds 70 in the largest specimens.

Pleopods. No trace of a protruding subterminal sexual process could be detected on the inner margin of the endopod in the two males examined (l.=19·6 and 21 mm. respectively, exclusive of the rostrum; text-fig. 4).

Sixth abdominal segment just over half the length of the carapace (·52–·59 : 1).

PALAEMON NILOTICUS Roux.

Roux, 1833, Ann. Sc. Nat. xxviii, p. 73, pl. vii, f. 2.
Klunzinger, C. B., 1866, Zeitschr. f. wiss. Zool. xvi, p. 357, pl. xx.
De Man, J. G., 1900, Trans. Linn. Soc., Zool. viii, p. 63.
Sollaud & Tilho, 1911, C. R. Ac. Sci. Paris, clii, p. 1868.

Locality.—LAKE RUDOLF :—

(*a*) Stn. 263. Open water near middle of lake : 10 specimens.

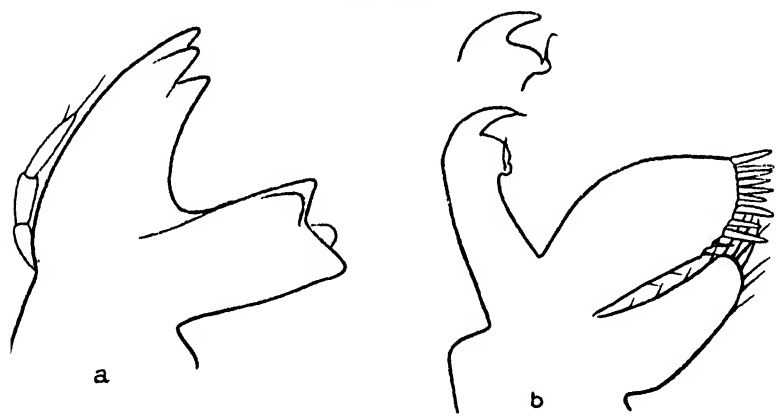
(*b*) Stn. 267. From stomach of *Lates* sp.?, caught at 50 metres depth near centre of lake : about 30 specimens all under 25 mm. in length.

(*c*) Stn. 275. Caught in trawl in Ferguson Gulf, depth 4 metres : 3 ♀♀ ; 4 ♂♂, two young specimens.

Description of female (l.=32·4 mm. ; from Stn. 275).—

Rostrum horizontal, a little longer than antennular peduncle, but hardly as long as antennal scale. Dorsal surface rather convex, armed with nine

TEXT-FIG. 5.



Palaemon niloticus Roux, ♀.
a. Part of mandible : ×47. *b*. Maxillula : ×60.

teeth, one of which is on the carapace ; distal fifth unarmed. Apex acutely lanceolate. A single tooth on the ventral surface opposite the distal articulation of the second segment of antennular peduncle. Accessory flagellum of *antennule* consisting of thirteen free segments ; antennal flagellum considerably longer than the total body-length (but not quite complete).

Mouth-parts very similar to those figured rather poorly by Klunzinger (1866, pl. xx, figs. 4-9) ; part of mandible and the maxillula represented in text-fig. 5, *a* and *b*. The third maxillipeds extend beyond the antennal peduncle by one-third the length of their last joint.

Peraeopods. The first peraeopod extends to the tip of the spine on the antennal scale. Carpus and merus equal (text-fig. 6, *c*, and Table II, ♀). Chela just over two-thirds of the merus ; fingers scarcely longer than palm.

Second peraeopod relatively slender, not quite half the total length of the body (1 : 2·4) ; reaching beyond the accessory antennular flagellum by about

half the length of the fingers. Carpus equal in length to merus and three-fourths of chela (Table II). Fingers one-third as long again as palm, straight, meeting along their whole length; inner margins with smooth cutting-edges without any trace of teeth; widely-scattered short setae on chela, but no trace of spinules; minute setae near inner margin of finger.

The succeeding pairs of peraeopods are long and slender, the fourth pair extending to the tip of the antennal scale. The dactyli are of approximately equal length, but the propodi increase as one passes backwards, so that the ratio propodus ÷ dactylus is 1·9 for peraeopod 3, 2·75 for peraeopod 5.

TABLE II.

Locality.	First peraeopod.			Second peraeopod.		
	Length of fingers *.	Length of chela †.	Length of carpus †.	Length of fingers *.	Length of chela †.	Length of carpus †.
Lake Rudolf, Stn. 275.						
♀$_1$ (l. = 32·4 mm.) ...	1·05	0·68	1·00	1·35	1·33	1·00
♀$_2$ (l. = 32 mm.)	1·2	0·67	1·06	....	....	....
♀$_3$	1·25	0·69	1·04	....	....	....
♂$_1$ (l. = 24·4 mm.) ..	1·13	0·64	1·00	2·25	1·77	1·07
♂$_2$	1·18	0·67	1·05	2·09	1·77	1·04
♂$_3$ (l. = 27·12 mm.) .	1·33	0·67	1·06	1·84	1·59	1·03
♂$_4$ (l. = 30·56 mm.) .	1·22	0·69	1·07	2·05	1·70	1·06
Nile.						
Bahr el Gebel, 1908.						
♀ (l. = 42·8 mm.) ...	1·0	0·6	1·20	1·06	1·13	1·25
Blue Nile, 1906.						
♀ (l. = 46 mm.)	1·14	0·56	1·20	1·03	1·18	1·33
White Nile, 1905.						
♀ (l. = 40 mm.)	1·17	0·53	1·16	....	....	....
♂ (l. = 34·56 mm.) ..	1·22	0·61	1·21	2·09	1·69	1·12
Korusko.						
♀	1·08	0·56	1·16	1·00	1·40	1·34
♂	1·21	0·54	1·15	2·20	1·60	1·16

End of *telson* very similar to that of *P. moorei* (Calman, 1899, P. Z. S. p. 710, pl. xi. fig. 241).

Uropod as represented in text-fig. 7, *b*.

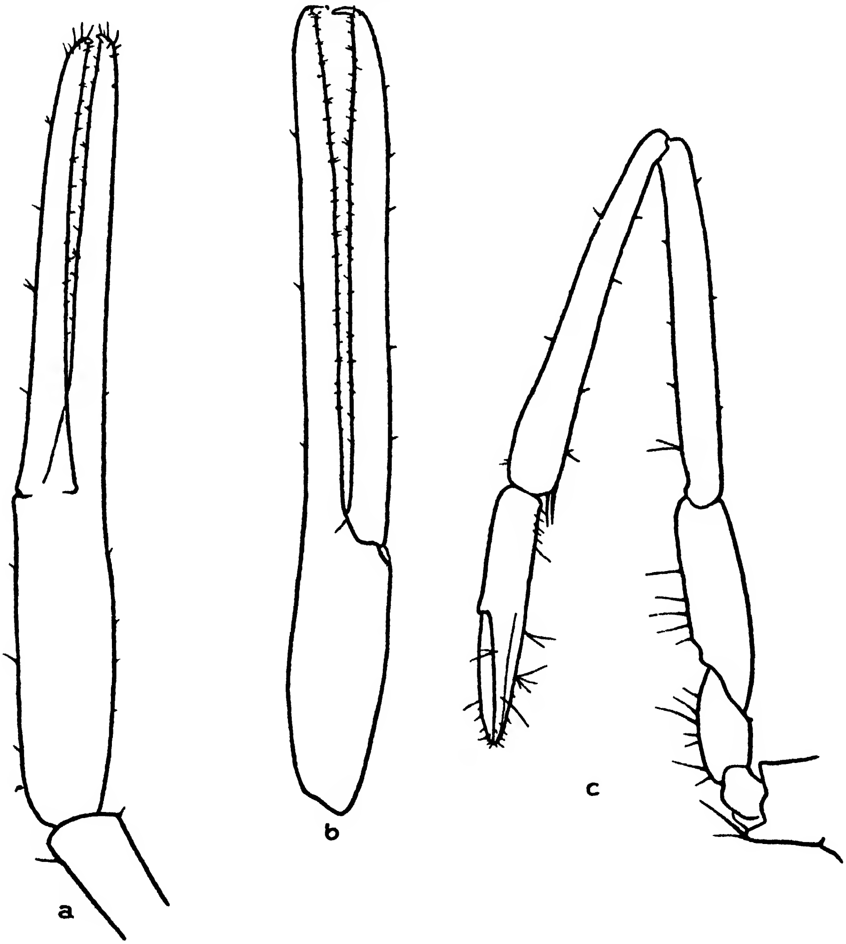
Size of *ova* (♀, Stn. 267) 1·16–1·24 × ·80–·88 mm.

The *male* is very similar to the female in general appearance. The second peraeopod is again scarcely half of the total body-length (1 : 2·13) and is not more massive than that of the female. It differs, however, in the relative proportions of the distal parts (Table II). The carpus is subequal to, but the

* Length of palm = 1. † Length of merus = 1.

chela is approximately three-fourths as long again as the merus. Also, the palm is much shorter relatively to the fingers (text-fig. 6, *b*). We cannot be certain that the chela of the males exhibits the fully adult characters, but the fact that a female (l.=22 mm.) from Stn. 267 is ovigerous proves that this is a very small form.

Text-fig. 6.



Palaemon niloticus Roux.

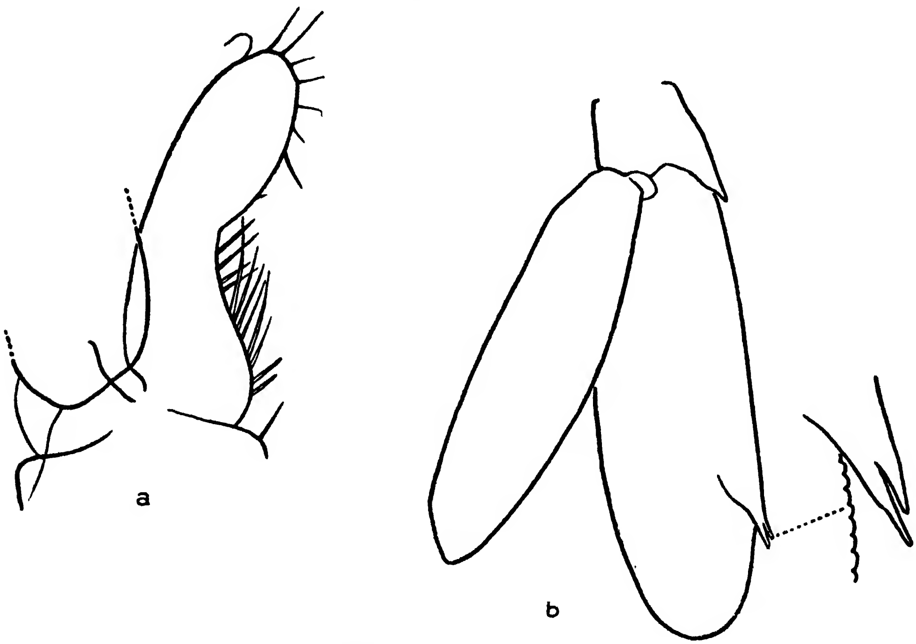
a. Chela of peraeopod 2 of ♀. *b*. Chela of peraeopod 2 of ♂.
c. Peraeopod 1 of ♂. ×27.

The endopod of the first pleopod is represented in text-fig. 7, *a*.

Remarks.—*Palaemon niloticus* does not appear to have been described since 1866, and Klunzinger's account is more or less defective. A number of specimens from the Nile in the British Museum Collection undoubtedly belong to this species. The greater number of the specimens, labelled 'Nile

Shrimps caught at Korusko, August 1861,' are in very poor condition, having apparently been dried. Four specimens from various localities were presented by Major S. S. Flower in 1905, 1906, and 1918. One of the latter, a female from the Blue Nile, differs from the Lake Rudolf specimen described above in several respects:—(1) The accessory flagellum of the antennule has 17–18 free segments. (2) The chela of peraeopod 1 is almost exactly half of the carpus as described by Klunzinger (Table II); the distal end of the carpus reaches to the tip of the spine on the antennal scale. (3) The second peraeopod is almost exactly half the total length of the body (1 : 2·06), and extends beyond

TEXT-FIG. 7.



Palaemon niloticus Roux.
a. Endopod of pleopod 1 of ♂ : ×90. *b.* Uropod : ×17 and 60.

the accessory flagellum of the antennule by almost the whole length of the chela. The fingers are shorter in proportion to the merus. (4) In both chelate peraeopods the carpus is considerably longer relatively to the merus (Table II). Some of these differences may be due to the larger size of the female in question, but those shown in Table II are of constant occurrence (mentioned in nos. 2, 3, and 4 above).

Although it is very probable that the Lake Rudolf specimens have not attained their maximum size, it is also likely that they represent a local race of *P. niloticus*, differing from the typical Nile form in the relative proportions of certain parts of the two chelate appendages. It is unfortunate that the Lake Chad material has not been described in detail.

The habits and feeding mechanism of the Amphipod *Haustorius arenarius* Slabber.

By Ralph Dennell, B.Sc., Research Assistant and Assistant Demonstrator, Department of Zoology, University of Leeds. (Communicated by Prof. W. Garstang, M.A., D.Sc., F.L.S.)

(With 13 Text-figures)

[Read 24 November 1932]

INTRODUCTION

The sand-burrowing amphipod *Haustorius arenarius* after special search was found in considerable numbers in Robin Hood's Bay, Yorkshire, and a study of its structure and habits was undertaken at the suggestion of Professor W. Garstang. Professor H. G. Cannon, after seeing one or two dead specimens, suggested that the animal probably fed by some filtering mechanism, and accordingly the feeding-habits have been examined in some detail. My thanks are due to Professor H. G. Cannon for his kindness and assistance.

Haustorius has been described and figured by Sars (1895), and by Chevreux and Fage (1925). Stebbing (1906) quotes the following synonyms for the genus *Haustorius* :—*Lepidactylus* Say (1818), *Pterygocera* Latreille (1829), *Bellia* Spence Bate (1851), and *Sulcator* Spence Bate (1854). For the species *Haustorius arenarius* he gives the synonym *Oniscus arenarius* Slabber (1769).

Spence Bate and Westwood describe the animal in their 'History of the British Sessile-eyed Crustacea,' but it is not clear whether or not they are confounding it with *Sulcator* (=*Urothoe*) *norvegica*. Sars suggests that most of the characteristics of the animal may be explained as adaptive modifications in relation to the mode of life. This view is amply corroborated by my own observations.

Hunt (1925) has discussed the feeding of several amphipods, and divides them according to their habits into suspension-feeders and detritus-feeders. He points out that there is no doubt a good deal of overlapping between these two divisions owing to the floor of the sea being in a labile condition, detritus being stirred up by the water and suspended organisms dying and becoming deposited on the bottom. The feeding of *Ampelisca* is briefly described. Apart from this paper I know of no other description of feeding in the Amphipoda.

A description of *Haustorius* from the point of view of its habits and feeding will be given later. The accounts given by Sars and by Chevreux and Fage

are excellent from the taxonomic standpoint, but are insufficient for the purpose of discussing movements and feeding. *Haustorius* feeds on fine particles of detritus, which are collected by a combined maxillary 'suction-pump' and filter-plate. Stebbing (1906) says of the animal that it 'burrows with great dexterity in wet sand. Will live long in suitable confinement.' These remarks are confirmed by my observations.

HABITS

(1) Occurrence.

Haustorius arenarius occurs all round the coasts of the British Isles, the coasts of France, the Kattegat, Holland, the east coast of North America, and the west coast of Norway, burrowing in the sand of the beach (Chevreux and Fage, 1925).

At Robin Hood's Bay, on the east coast of Yorkshire, considerable numbers have been found, and the occurrence of the animal here is interesting in that, although a sand-inhabiting animal, there is very little sand on this part of the coast. The distribution of the animal in this bay is so intimately bound up with the physical features of the bay as to merit description.

It will first be necessary to outline the topography of the bay, which is about three miles wide. At low tide the sweep of the bay is broken by a series of reefs running out to sea at right-angles to the shore (text-fig. 1). These consist of fossiliferous shales of lower Liassic age, dipping gently to the north and broken into low scars on the southern side of each reef. By far the greater part of their surface is covered by littoral algae or encrusted with barnacles, but in one place, about the middle of the bay, there are deposits of fine clean sand between the scars, and it is in this sand that *Haustorius* is to be found. Nowhere does this sand exceed a depth of more than two to three feet. (These sands are continually shifting; this observation was made in the summer of 1928.)

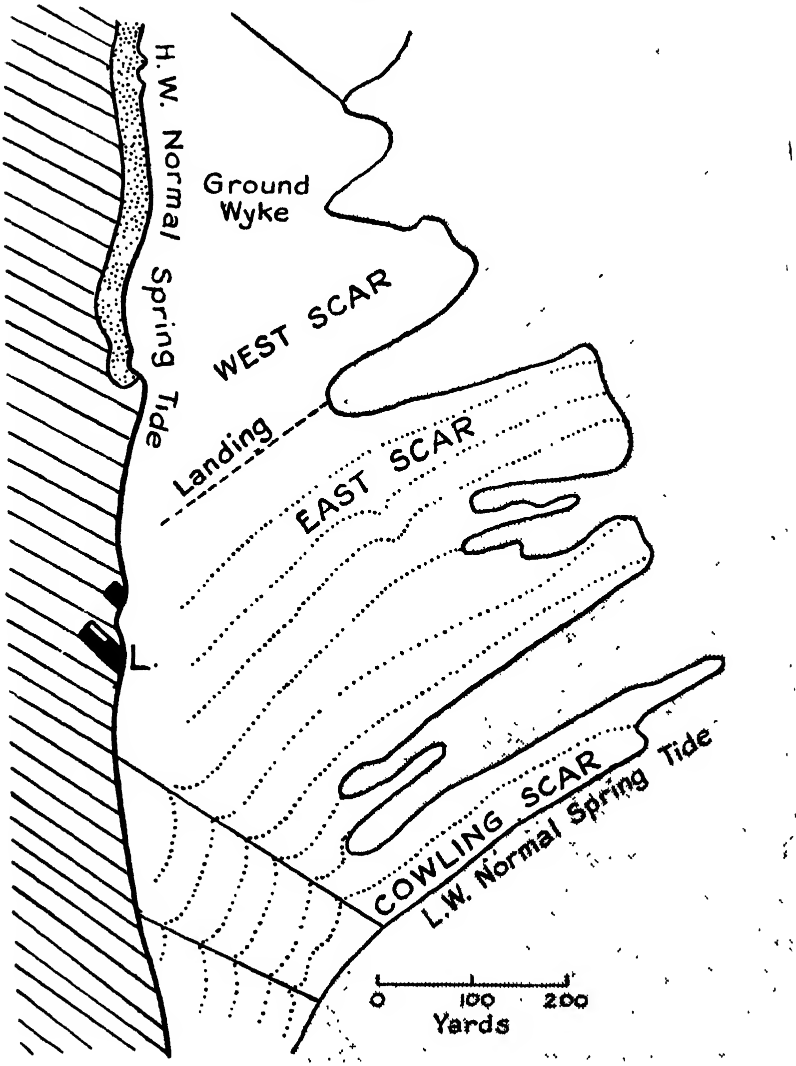
Apart from the sand lying between the scars, there are tracts of sand bordering a stream, Mill Beck, which flows into the bay. *Haustorius* is also found in these sands. The animal is never found in sand which shows any tendency towards drying up or which contains much debris (Table I).

By digging in various directions in the sand it was found possible to obtain some estimate of the frequency of occurrence of the animal. The trenches were 10 feet long and 1 foot wide and deep. The sand from the trenches was carefully examined by passing through the hands. If this is done thoroughly it is probable that very few of the larger animals are passed over.

The organic matter present as detritus in the sand varies in quantity from place to place, and is in a finely divided condition. When observed in small sand samples under the binocular microscope it appears as flocculent particles, very much smaller than the sand-grains. It is probably mainly derived from the attrition of the littoral algae.

Sand-samples were taken from various positions at the bases of, and between, the scars, and their organic content determined by first drying

TEXT-FIG. 1.



The Scar system in Robin Hood's Bay. L.=Leeds University Biological Laboratory.

thoroughly and then igniting at a heat just below redness to remove the organic matter. The loss in weight after ignition gives an indication of the organic content of the sand.

TABLE I.

No.	Position of Trench.	No. of Animals.	Remarks.
1.	At base of scar and parallel with L.W.	4	Sand very wet.
2.	At base of scar and almost parallel with L.W.	—	Much black debris in sand.
3.	At base of scar and parallel with L.W.	—	Much weed-debris, ashes, coal, etc., in sand.
3.	Same scar as above: similar position, but 10 yards away.	—	Ditto.
3.	Ditto.	—	Ditto.
4.	At base of scar and parallel with L.W.	14	Moderately wet clean sand.
4 *a*.	Parallel with L.W., but 6 feet from base of above scar seaward.	2	Clean and wet.
5.	At base of scar and parallel with L.W.	—	Wet fine sand. Some black debris.
6.	Ditto.	—	Ditto.
7.	Parallel with L.W., but 20 feet from base of above scar seaward.	1	Ditto.
8.	At base of scar and parallel with L.W.	7	Clean wet sand. No debris.
9.	Ditto.	—	Much black debris. Sand moderately wet.
9 *a*.	Parallel with L.W., but 10 feet from base of above scar seaward.	5	Clean wet sand. No debris.
10.	At base of scar and parallel with L.W.	2	Some debris. Very wet sand.
11.	Ditto.	—	Dry sand: little debris.
12.	Ditto.	—	Ditto.

Trenches in sand with varying amounts of debris.
For explanation, see base of Table II.

TABLE II.

No.	Position of Trench.	No. of Animals.	Organic content of sand (per cent.).
1.	Parallel to scar and near to its base	72	1·08
1 *a*.	Parallel to trench 1, but 4 feet nearer L.W........	49	·96
2.	Parallel to base of scar and near it	34	1·10
3.	Parallel to base of scar and near it	24	1·02
3 *a*.	Parallel to trench 3, but 6 feet nearer L.W.	10	·94

These trenches were dug in fine clean sand, and were each 10 feet long and 1 foot wide and deep. The numbers in the left-hand column refer to the distance of the trenches from the low-water level (e.g. 1 denotes the first scar landwards from low-water level, 2 the second, and so on.

Table II. shows the number of animals and the organic content of the sand found in various positions. Since the animals feed by filtering small food-particles from the surrounding water, it is probable that variations in the organic content of the sand will influence their local distribution. As receding waves pass over the scars a backwash current will be produced, and possibly this current may deposit detritus in the deep sand at the bases of the scars.

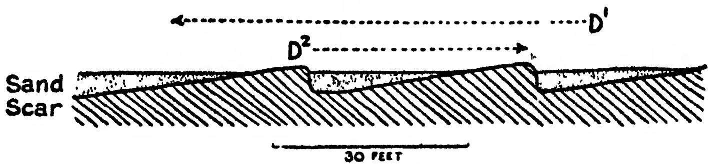
Another factor influencing local distribution of the animals is the water-content of the sand. It is seen from Table I that the animals are more numerous at the bases of the scars than between them. The spaces between the scars resemble long shallow troughs (text-fig. 2), and the deepest parts of these troughs are situated at the bases of the vertical faces of the scars. Towards the sea the troughs become shallower. The troughs are filled with sand, and water left behind as the tide recedes will tend to collect in the deeper parts at the bases of the scars. Since the burrowing power of the animal is due to the powerful current expelled by the pleopods, therefore rendering the animal unable to burrow in dry sand, the high frequency of occurrence of the animal at the bases of the scars may be due to burrowing being easiest there. Also, since feeding is dependent on a current of water produced by the maxillæ, it will be most easily carried on there. There is thus a diminution in numbers of animals on each scar from the base towards the sea (text-fig. 2, D^2).

Considering the scar system as a whole, the animals are most numerous on the scar nearest low-water mark, and are progressively fewer on succeeding scars towards high-water mark. This is due to the tendency of the animals to congregate in the wettest sands, those nearest low-water mark, and thus

they show a diminution in numbers on the whole beach, passing landwards (text-fig. 2, D[1]). There is thus a primary diminution, D[1], up the beach as a whole, and a secondary diminution, D[2], in the reverse direction on each individual scar, both being accounted for by the water-content of the sand. The possibility that the greater protection given to the animals at the bases of the scars may also influence their abundance there is not to be neglected.

Haustorius apparently may forsake the sand at periods of high water to swim freely. Scott (1922) found individuals in the stomachs of young plaice (27–78 mm. in length), and, since the young plaice feed almost entirely on the pelagic and semi-pelagic invertebrate animals living in the water through which they move, it would appear that *Haustorius* does leave the sand during high-water periods. The same author also states that in the Morecambe Bay area a tow-netting taken a few yards out from the shore, and in not more than two feet of water, usually contains such truly pelagic forms as *Calanus* and *Temora*, along with the bottom-living Cumacea and Amphipoda (cf. 'Tropisms,' p. 374).

TEXT-FIG. 2.



The scars in transverse section.

The sand on the scars contains a few small Nereid and Sabellid worms and the Amphipod *Sulcator* (=*Urothoe*) *norvegica*. With the exception of these and occasionally a few sand-eels (*Ammodytes lanceolatus*), no other animals have been found in the sand. No large masses of detritus are to be seen in the sand, and from an examination of the sand it would seem that feeding must take place on small particles rather than on large masses. The action of the sand, set in motion under the influence of wave action, will result in the comminution of all organic material down to a uniform fine grade (Bruce, 1928).

(2) MOVEMENTS.

It will now be necessary to give a description of the animal from the standpoint of its habits.

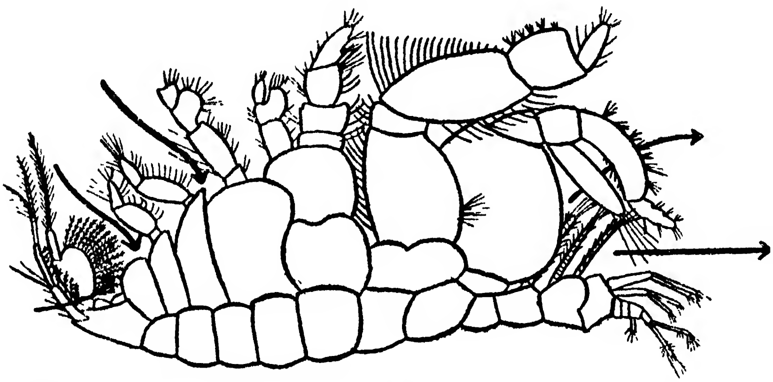
The body is broadly arched, the lateral compression typical of so many of the Amphipoda being almost completely lost. The coxal plates are large, and these, together with the broadly arched body, give the animal a boat-shaped appearance when swimming upside down. The joints of the last three pairs of pereiopods are broadly dilated into flat laminae, and these overlapping form with the coxal plates a wall on each side of the body (text-fig. 3).

There is, then, a tunnel-shaped space between these walls and the body above, and this is of the greatest importance in the rapid burrowing for which the creature is remarkable. The plentiful setal armature of the three pairs of pereiopods interlocking and overlapping enhance the efficiency of this wall.

The first and second pairs of pereiopods possess posteriorly on the carpal joint a rounded lamellar expansion, and the outer part of the propodial joint is obtusely rounded, thus forming a shovel-like structure.

The peduncular joints of the antennae are obtusely rounded in a similar manner to the propodial joints of the first two pairs of pereiopods, and are in addition provided with a dense fringe of marginal setae, copiously feathered. The peduncular joints of the antennules are rounded in a similar manner, but to a far less extent. The pleopods are extremely powerful, their bases

TEXT-FIG. 3.



Haustorius in the swimming position, showing the main currents produced.

possessing on their inner margins a pair of coupling-hooks, which lock each pair of pleopods together. The setae of the pleopods are rather stout proximally, and not plumose, while distally they are more slender and densely plumose. The setae of each ramus of a pleopod interlock and form a dense mat, so that in effect each pleopod presents a flat, water-resisting surface to the rear.

The uropods are very stout, and are directed upwards and backwards, and provided with strong spine-like setae.

Not only is the lateral compression typical of the Amphipod lost in *Haustorius*, but the flexion of the body is very greatly reduced. This flexion probably prevents an Amphipod such as *Gammarus locusta* from swimming in a regular manner, as a curved body travelling through a dense medium such as water will tend to follow a curved path. *Haustorius* is beautifully constructed for swimming and burrowing.

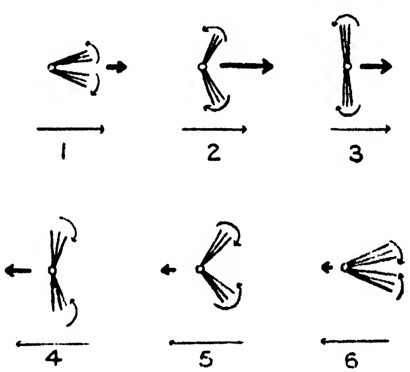
The eyes are small and white in young specimens, but in older animals they may become almost invisible.

All the specimens collected at Robin Hood's Bay were females. Sars (1895) figures only the female, and Chevreux and Fage (1925) state that the male is unknown.

(a) *Swimming.*

Haustorius swims on its back (text-fig. 3) in a very graceful manner, performing evolutions quite impossible to such an Amphipod as *Gammarus locusta*. Whereas *Gammarus locusta* depends on the rapidity of its movements for support in the water, *Haustorius* is able to swim quite slowly—indeed, it can hover almost in one place for a considerable time. This power of swimming with ease, though not rapidity, is conferred by the broadly arched body, the vertical plates formed by the coxal plates and expanded joints of the last three pairs of pereiopods, together with the setae borne by the antennules and antennae. Thus the animal presents a considerable surface-

TEXT-FIG. 4.



Showing diagrammatically the movements of the setae with respect to the ramus of a pleopod during its beat. (The direction of motion of the ramus is indicated by a thin arrow below it; the current produced is represented according to its strength by the length of the heavy arrow; and backwash currents are shown by the thin curved arrows.)

area to the water when swimming, and this large exposed area, although it increases the resistance of the animal to forward motion, and so makes swimming slower, also increases its resistance to downward falling through the water. In effect, the antennules, antennae, coxal plates, and pereiopods serve as organs of flotation.

It has already been remarked that the shape of the body when swimming is perfectly boat-like. The powerful swimming current is produced by the rhythmical beating of the three pairs of pleopods, and a few remarks on the current production by the pleopods will not be out of place.

In text-fig. 4 is shown a ramus of a pleopod in six different positions. The currents produced are represented by arrows on the limb, and the direction

in which the limb is moving is shown by the arrow below. Considering first the third position of the limb, it has almost reached its limit of travel in a backward direction. The setae of the pleopods are so attached as to be able to move over a considerable range with regard to the axis of the limb, and it is this fact which is responsible for the efficiency of the pleopods as a propelling mechanism. The setae in position 3 of the pleopod have been forced to extend laterally from the axis of the limb by the pressure of the water on them, and in this position they offer their maximum resistance. As the limb is moving backwards a powerful backwardly directed current will be produced.

In position 4 the limb has commenced its forward stroke, and the resistance of the water, acting now on the anterior face of the pleopod, causes the setae to stream out behind the axis on the whole of the forward stroke. The effective area of the pleopod is thus reduced, and the forwardly directed current produced on the forward stroke of the limb is very feeble compared with that produced on the back-stroke. The setae are seen trailing behind the axis in positions 4, 5, and 6. In position 1 the limb has begun to travel backwards again, and the setae are beginning to spread out laterally again, which they complete in positions 2 and 3.

If no provision were made for the collapse of the pleopod setae on the forward stroke—that is, if both back and forward movements of the pleopod produced currents of the same strength—no backwardly directed swimming current would be produced, for this current would be annulled by an equally powerful forwardly directed current. The only result of the beating of the pleopods would be to produce a violent agitation of the water in the neighbourhood of the pleopods in a series of eddy currents. The pleopods inevitably cause backwardly directed currents round the axis of the limb on the forward stroke, and forwardly directed currents on the back-stroke, but these eddy currents are feeble in comparison with the powerful backwardly directed swimming current, and do not greatly reduce the efficiency of the pleopods as a swimming mechanism.

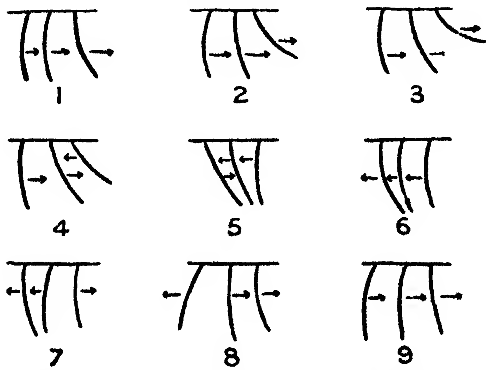
An arrangement which increases the efficiency of the pleopods is seen in the coupling-hooks or spines on the inner sides of the bases of the pleopods. By their agency the bases of the pleopods are linked together, so ensuring that the pairs of pleopods beat together.

So far the beating of one only of the three pairs of pleopods has been considered. A moment's observation of the animal shows, however, that all the three pairs of pleopods do not perform their beat together; they do do so out of phase with each other. This difference of phase is of a particular type—that known as metachronial rhythm, in which, in a series of appendages, any one appendage begins its beat immediately before the appendage in front of it (text-fig. 5). Such a rhythm is of fundamental importance in producing a steady current instead of a series of sharp jets of water. In addition, the effectiveness of each of the pairs of pleopods is increased. If all the three

pairs of pleopods performed their beats together, the current produced would be little, if any, more powerful than that produced by the last pair alone, as each of the first two pairs would be travelling in the backwash current produced by the pair behind, a condition not conducive to efficiency in any paddle system.

Actually, under the influence of metachronial rhythm, a pair of pleopods can work undisturbed by the effects of the other pairs. In the case of the last pair of pleopods, their back-stroke produces a powerful backwardly directed current, but as the pair of pleopods in front is lagging, the space between these two pairs is increased. Water flows in to fill this space, and it is this water which is set in motion by the back-stroke of the second pair of pleopods. The posterior pair do not impede the outflow of the swimming-current produced

TEXT-FIG. 5.



Showing diagrammatically the movements of the pleopods during a single beat.

by the middle pair, as they are at the end of their back-stroke and are momentarily lying almost flat beneath the abdomen. The same happens with the first two pairs of pleopods.

The pleopods, then, working with a beautiful mechanical nicety, produce a steady powerful swimming current passing backwards beneath the abdomen. The reaction of this current on the pleopods propels the animal through the water.

Steering is effected mainly by the last pair of pereiopods. The expanded joints of these limbs, extended backwards parallel to the direction of motion, serve as a pair of 'rudders' below the pleopods. The position of the 'rudders' is of interest, for the water flowing past them is expelled by the pleopods and is travelling faster with respect to the body than the water passing the body more anteriorly, when the animal is in motion. The reaction of the water on the steering limbs is therefore greater than if more anterior limbs performed the function of steering, and so increased control over the swimming movements is given.

Possibly the large coxal plates and dilated joints of the pereiopods may serve to prevent rolling of the body when the animal is swimming, as any side to side movement will be checked by the opposition of a large flat surface to the water.

(b) *Burrowing.*

The method of burrowing is of interest, for instead of the sand being scooped away by the digging action of the limbs, it is expelled by the action of the powerful current produced by the pleopods. It is true that the first two pairs of pereiopods do serve to a slight extent in digging, but the chief agent is the expulsive action of the swimming stream, aided to some extent by the uropods.

As has been mentioned before the coxal plates and the large expanded lobes of the three pairs of pereiopods form vertical walls below the body, so that the space enclosed below the body is of tunnel-section. Furthermore, numerous long setae borne marginally on the joints of the last three pairs of pereiopods project inwards below and across this space, so that there is an almost completely enclosed tubular space below the body.

A swimming individual sinks to the surface of the sand in the tank and immediately rights itself, so that the ventral surface is once more downwards. The pleopods continue their action, so that a current of water passes backwards under the body, enters the 'tunnel,' and is violently expelled to the rear. This current is sufficiently powerful to cause sand-grains to be carried along with it, so that sand is removed from the region at the front of the animal, through the 'tunnel,' and is cast out behind. Also, since the animal is burrowing in sand submerged below water, the swimming action of the pleopods drives the animal against the sand in front of it, so that a tendency of the head to bore into the sand is given. The expanded second and third joints of the antennae, lying at an acute angle to each other, with the apex pointing forwards, may serve to deflect sand to each side of the body.

When an individual is beginning to burrow, the abdomen may occasionally be seen to become flexed downwards and then suddenly straightened. The effect of this is to give the stout spiny uropods a purchase on the sand, and then by the straightening of the body the animal is pushed forwards and downwards into the sand. While these operations are being carried on, the first and second pairs of pereiopods are assisting the burrowing by scraping the sand, which, when loosened, will be carried away by the backwardly flowing current. The digging effect of the pereiopods must be small compared with the action of the current in removing sand.

It will be noted that the movements in swimming and burrowing are fundamentally the same, each depending on the production of a powerful current by the pleopods. Obviously the 'tunnel' effect of the coxal plates and the third, fourth, and fifth pairs of pereiopods contributes in large measure to the efficiency of the water-current in expelling sand, for, were it not for this, water, instead of streaming directly backwards beneath the

body, would stream inwards to the pleopods from all positions around the body. In addition to this, the confining of the current in a 'tunnel' has the effect of increasing the velocity of the current, and also therefore its carrying power.

A large *Haustorius* will produce a current sufficiently powerful to throw the sand out behind it in the water to a distance of almost an inch when beginning to burrow.

Individuals have never been observed to burrow in sand that is not completely saturated with water. For instance, animals placed on the beach on the surface of the sand are incapable of burrowing and are completely helpless. This is, of course, due to the fact that burrowing is dependent upon an expelled current, and hence lack of water puts the burrowing mechanism out of action.

(c) *Tropisms.*

When swimming, the animals are positively phototropic. A parallel beam of light two inches wide was thrown across a tank in which individuals were swimming. When their casual movements brought them into the beam, the animals immediately orientated themselves so as to face the source of light. After swimming along the beam towards the light until reaching the side of the tank, they would remain for some time endeavouring to swim forward, and then fall to the sand and immediately begin to burrow.

Animals kept in captivity showed for some days after capture a diurnal rhythm in their swimming activities above the surface of the sand. During the day, from about 6 a.m. to 11 p.m. they remained quiescent, burrowing beneath the sand. After 11 p.m. until about 6 a.m. individuals were to be seen swimming freely in the water above the sand. Observations were made during the day and night, and at night a light was only used for a short period at intervals to note the numbers of animals swimming.

(3) Breeding.

It is interesting to note that the male of *Haustorius arenarius* is unknown (Chevreux and Fage, 1925). Of over 120 specimens examined all were females possessing oostegites, or lacking them, but resembling those so provided in all other respects.

Some of the individuals kept in the tank were found to be carrying eggs in the brood-chambers at the end of February, but none of the eggs developed into embryos. In this connection the work of Blegvad (1924) may be mentioned. He finds that many of the Gammarids are annual species, dying in the spring, after the embryos have become free. Some individuals breeding later in the summer may survive through the following winter and so carry the species on from one year to the next.

Haustorius also may be an annual species, for from the beginning of February animals in the tank began to die in considerable numbers, although none

of the individuals ever produced embryos. It may be that the heavy death-rate was due to some poisonous substance which had accidentally entered the tank, but if this were so it is not clear what the substance was and how it entered the tank, for care was taken to keep the tank scrupulously clean.

In the spring (April) of 1928 several specimens were found at Robin Hood's Bay, while in July 1928, the animals were abundant, and again in October of the same year. In March 1929 a great scarcity was apparent, only seven specimens being taken after a laborious search.

Whether reproduction takes place parthenogenetically, or whether there may be a male of the species, is unsettled.

THE FEEDING MECHANISM

(1) Methods.

The filtering mechanism of *Haustorius* depends for its action on the interlocking and particular arrangement with respect to each other of numerous series of setae, which cannot be clearly seen if ordinary methods of dissection are used. The method used for *Haustorius* was first to embed the animal in celloidin, followed by embedding in wax. With a sliding microtome the animal was cut into thick sections or slices, about 0·3 mm. thick, which were mounted unstained in balsam, the cover-glass being supported by fragments of broken cover-glass. By examination of these slices the arrangement of the setae and the disposition of the mouth-parts could be clearly made out. I am indebted to Professor Cannon for showing me his method (described by Cannon, 1927).

By dissecting off the individual mouth-parts their structure was determined, although by this means no reliable information on their arrangement *in situ* was obtained. Appendages were removed and cleared in glycerine, and examined under the microscope.

Animals were observed feeding by attaching them to the bottom of a glass capsule with plasticine, and supplying them with suspensions of various substances. Suspensions of starch stained with iodine, carmine, charcoal, iron saccharate, and mud were used, but by far the most satisfactory was a suspension of starch stained with iodine. The particles are not rejected by the animal, and owing to their deep blue colour are easily seen, and their progress in the food-stream followed.

A very useful source of information was given by leaving the animals for a day in a suspension of iron saccharate. Particles adhere to the filter-setae and mouth-parts, and, by cutting sections of such animals, the passage of food-particles can be followed, and also the limbs and setae concerned in feeding can be distinguished. For the time required for observation the animals appear quite healthy in iron saccharate, as Cannon and Manton (1927) found for *Hemimysis*.

(2) Relations of mouth-parts.

Before discussing the feeding mechanism it will be necessary to describe the relations of the mouth-parts to each other.

The mouth-opening is situated ventrally, and is bounded anteriorly by the large labrum, posteriorly by the well-developed paragnaths, and laterally by the molar and incisor processes of the mandibles. The mouth leads almost vertically upwards by a short oesophagus into a proventriculus or crop,

Text-fig. 6.

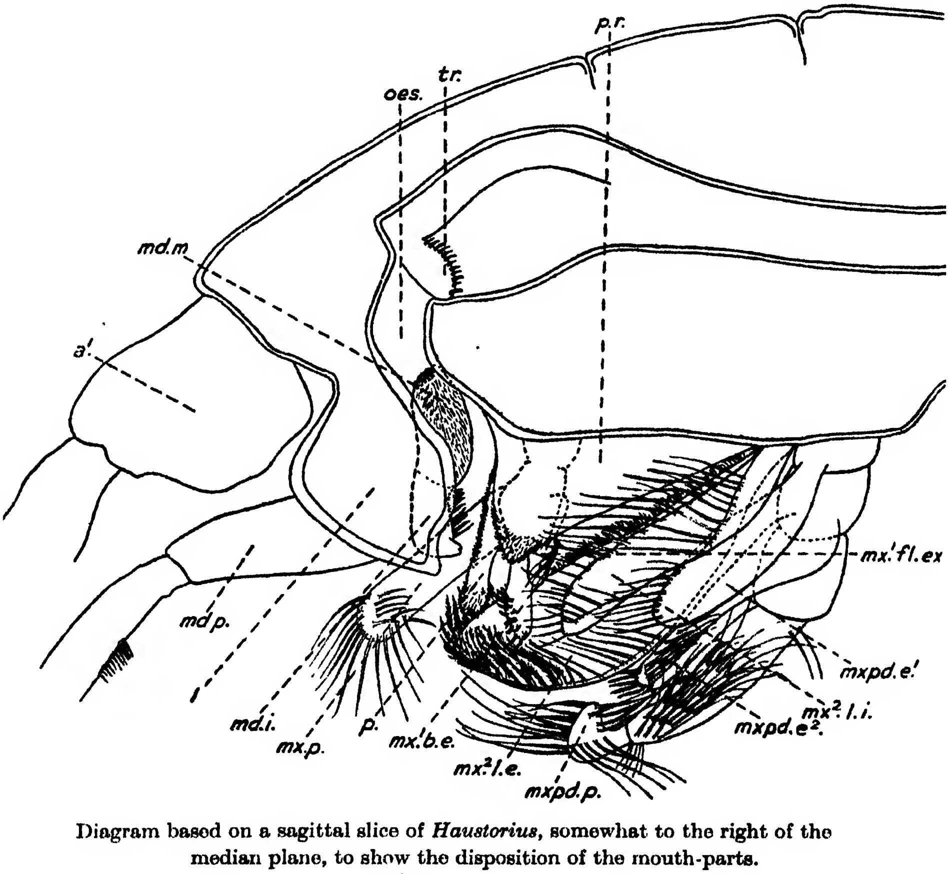


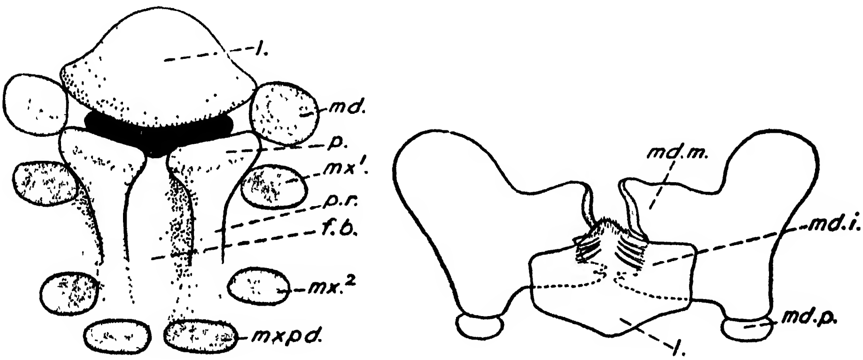
Diagram based on a sagittal slice of *Haustorius*, somewhat to the right of the median plane, to show the disposition of the mouth-parts.

provided with a 'Triturationsapparat' (a ring of chitinous teeth situated anteriorly) and a gastric mill (text-fig. 6). The labrum projects ventrally, and its anterior face is convexly rounded, while the posterior face has the form of an obtuse V, with the apex directed backwards. Internally are muscle-bands attached to the labrum and to the chitinous endoskeleton. The posterior face of the labrum is armed with short dense setae.

The paragnaths consist of two ridges, projecting ventrally at each side of, and parallel to, the mid-ventral line, and with their anterior ends flattened and closely applied to the posterior faces of the mandibles. Enclosed between the ridges of the paragnaths is a shallow depression, the 'food-basin' (Cannon and Manton, 1927), around which are grouped the posterior pairs of mouth-parts (text-fig. 7, *left*). The tips of the paragnaths are armed with setae similar to those of the labrum.

The setae of the labrum and paragnaths project backwards and forwards respectively over the space below the mouth-opening, so that the unobstructed entrance to the mouth lies posteriorly between the paragnaths.

TEXT-FIG. 7.



(*Left*) Diagram to show the labrum and paragnaths of *Haustoruis* in ventral view. The shaded areas represent the bases of the limbs, which have been removed. (After the diagram given by Cannon and Manton for *Hemimysis*.)

(*Right*) Diagram based on a transverse slice of *Haustorius*, a little in front of the mouth, to show the labrum and mandibles, viewed from in front.

The mouth-appendages.

The mandibles (text-fig. 7, *right*) are inserted laterally to the mouth, and the incisor and molar regions project inwards between the labrum and paragnaths. The incisor region consists of a double sharp tooth ventrally, immovable with respect to the remainder of the mandible. Proximally to this there is a row of blade-like spines with serrate margins. The left mandible possesses a lacinia mobilis below the row of blade-like spines and above the double tooth. The molar region of the mandible is rounded, and is covered with a dense layer of exceedingly fine, strong setae, so that its surface is almost file-like.

The mandibular palps consist of three joints, the first being short and the remaining two longer and almost equal in size. The penultimate joint is armed with scattered, stout, spine-like setae, but the tuft of setae at the tip of the distal joint is composed of spines stout proximally, becoming more

slender distally, and slightly hooked at the tips. The distal joint of the palp bears about the middle of its length a compact row of short feathered setae ('comb-row,' *md.p.c.r.*, text-fig. 9).

The maxillules (text-figs. 8 & 12, *left*), are situated somewhat behind the mouth and are opposed in the middle line. The biting endite ($mx^1.b.e.$) is armed with a row of blade-like setae like those on the incisor portions of the mandibles. Proximal to the biting endite is a flap-shaped expansion, with

Text-fig. 8.

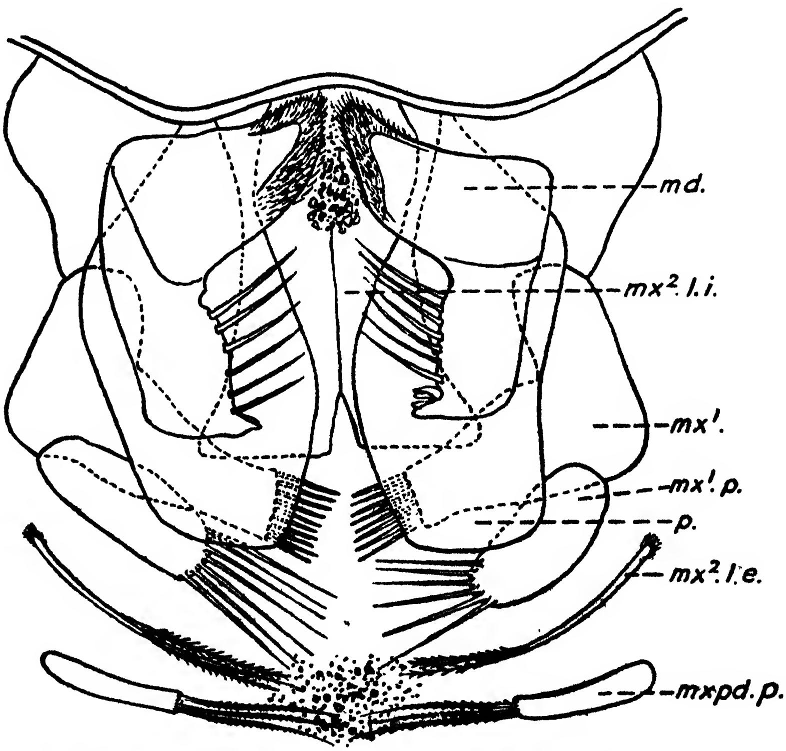


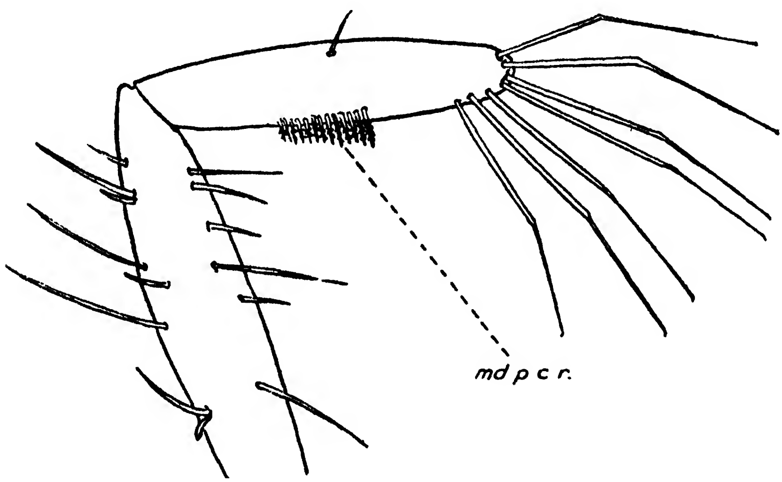
Diagram based on a transverse slice of *Haustorius*, a little behind the mouth, to show the paragnaths and maxillules, viewed from behind.

a row of long spine-like setae. These rows of setae project into the food-basin space immediately behind the paragnath-tips (text-fig. 8). The maxillulary palp is well developed, and at the tip is a tuft of long spine-like setae. About a third of the length of the palp from its proximal end is a tuft of a few long feathered setae. The outer margin of the basal portion of the maxillule is fringed with closely-set short setae. The maxillules are closely applied to the posterior faces of the flattened paragnath-tips.

The maxillae (text-figs. 10 & 12, *right*) are attached some distance behind the maxillules, leaving a space between these two pairs of appendages. Each

maxilla is composed of two lobes, a large delicate outer one (*mx*^{2}.*l.e.*) and a smaller stouter one. The outer thin lobes are described by Sars (1895) as being semilunar in form. They are so curved as to form a concave depression on their morphological anterior surfaces. The outer margins and the tips of the lobes are curved upwards, so that the two lobes, apposed to each other, form a scoop-like structure. The maxillae do not project vertically downwards, but, rising from the body just behind the posterior limit of the paragnath-ridges, lie almost horizontally beneath the food-basin, with the tips of the large outer lobes touching the paragnath-tips (text-fig. 8). A space is thus enclosed beneath the food-basin, the short densely arranged setae on the outer margins of the outer lobes touching the ventral surface of the body, outside the paragnath-ridges. In the middle line between the maxillae a dense

TEXT-FIG. 9.



The last two joints of the mandibular palp of *Haustorius*, to show the comb-row of setae (*md.p.c.r.*) on the last joint.

sieve of setae is formed by the interlocking of the moderately long simple setae fringing the inner margins of the inner lobes.

The maxillipeds (text-fig. 11) are inserted behind the maxillae, and lie close beneath them almost parallel with the lower surface of the body. They consist of a basal portion, composed of the proximal joints of each side incompletely fused together, and arising from them on each side a masticatory lobe (lobe intérieur: Chevreux and Fage). These lobes are armed marginally with a row of short stiff setae. The palps are composed of three joints, the first being small, the second the largest, and the distal joints bent at right angles. The proximal joint possesses a few long spine-like setae, while the distal joint is plentifully armed with long stout serrate setae. The second joint of the palp bears numerous parallel rows of short stiff setae arranged

like the teeth of a comb. These 'comb-rows' project vertically upwards from the palp and lie immediately beneath the filter-setae (sieve) of the maxillae. The palps of the maxillipeds lie above the masticatory lobes. The basal joints of the maxillipeds are provided on their inner margins with short sharp setae, and the tips of these endites possess similar but longer setae forming a dense tuft.

TEXT-FIG. 10.

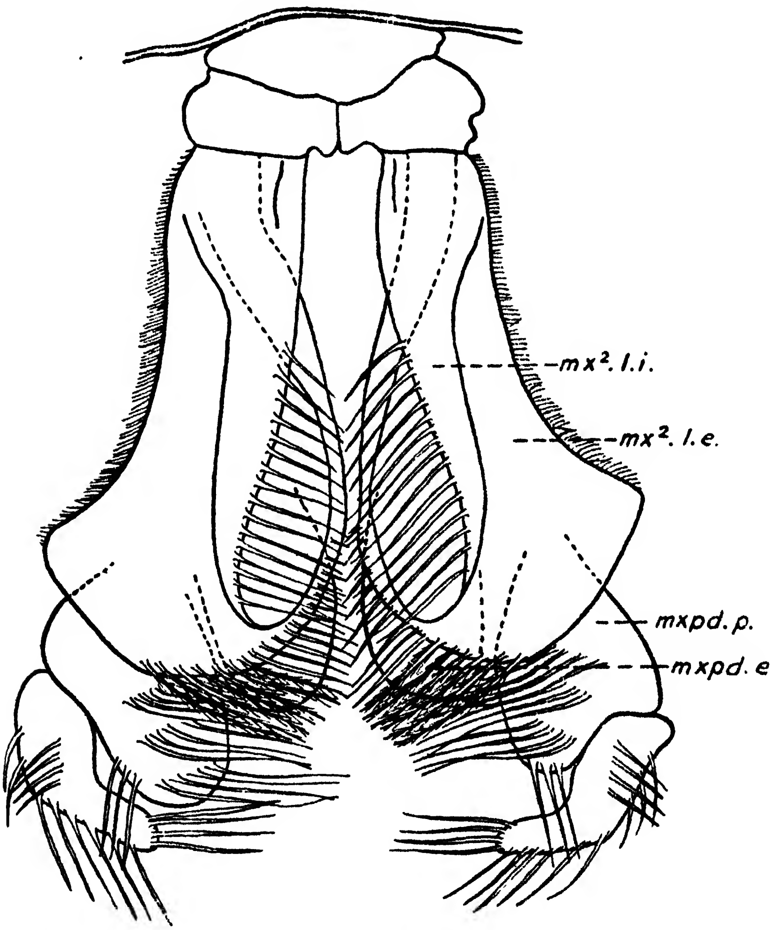


Diagram based on a transverse slice of *Haustorius*, to show the position *in situ* of the maxillae and maxillipeds, viewed from in front.

(3) FEEDING ON SMALL PARTICLES.

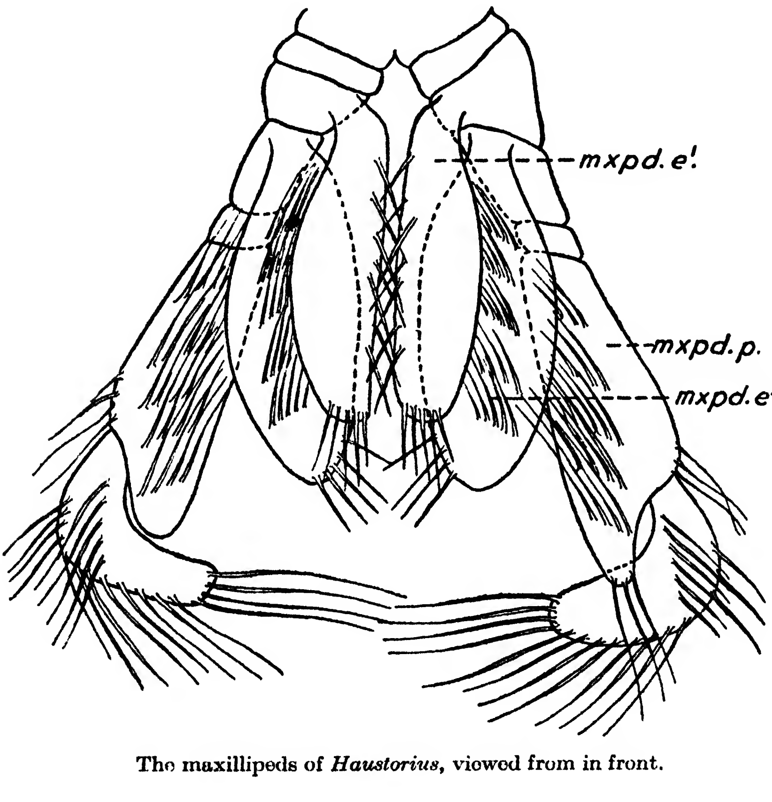
As has been mentioned before, the sand in which *Haustorius* lives contains small flocculent particles of organic detritus. *Haustorius* feeds largely by filtering these from a stream of water produced by the mouth-parts. The

appendages concerned in producing this current and filtering it are the maxillae, which act as a combined suction-pump and filter-plate, while the maxillipeds remove food-particles from the maxillae and pass them forward to the mouth.

Movements of the maxillae.

The movements of the maxillae are almost purely rotatory, with the axis of rotation lying almost on the outer margin of the large outer lobe. Thus

TEXT-FIG. 11.



The maxillipeds of *Haustorius*, viewed from in front.

on rotation of the limb the inner margins of the lobes describe a wide sweep outwards and downwards, while the outer margins of the lobes are shifted slightly upwards and pressed against the lower surface of the body. If the movement of the maxillae were purely rotatory, the inner margins of the maxillary lobes would describe an arc of a circle, but actually they sweep downwards at the beginning of a beat, the limb begins to rotate, and their movement becomes directed outwards. The limbs pass through the same positions in returning to the starting-point of a stroke.

The food-basin space is continually being enlarged and diminished by the action of the maxillae, and as water must flow in and out of the space as it changes in volume the feeding current is set up.

The flow of the water entering and leaving the food-basin is directed and controlled by the setae of the maxillae.

When the food-basin is enlarged (that is, on the outward stroke of the maxillae), the ventral gap between the two maxillae is increased, but this, owing to the motion of the maxillae, takes place towards the *end* of the stroke. Water flows in through this ventral gap, which is closed by the sieve of setae on the inner margins of the maxillary lobes, and food-particles are deposited on the sieve-setae. The food-basin is now full, and the return stroke commences. At the *beginning* of the stroke the gap between the maxillae closes and water is unable to escape here.

The arrangement of the setae on the tips of the large outer lobes of the maxillae, touching the paragnath-tips, has been described. These setae act as non-return valves, preventing the inflow of water to the food-basin space on the outward stroke of the maxillae, but permitting its outflow on the return stroke. Water leaves the food-basin space anteriorly through these setae, and food-particles which have escaped the marginal setae between the maxillae are retained here.

The maxillae function then as a combined suction-pump and filter-plate, the filtering regions of the maxillae being the marginal setae between the inner lobes and the setae at the tips of the outer lobes.

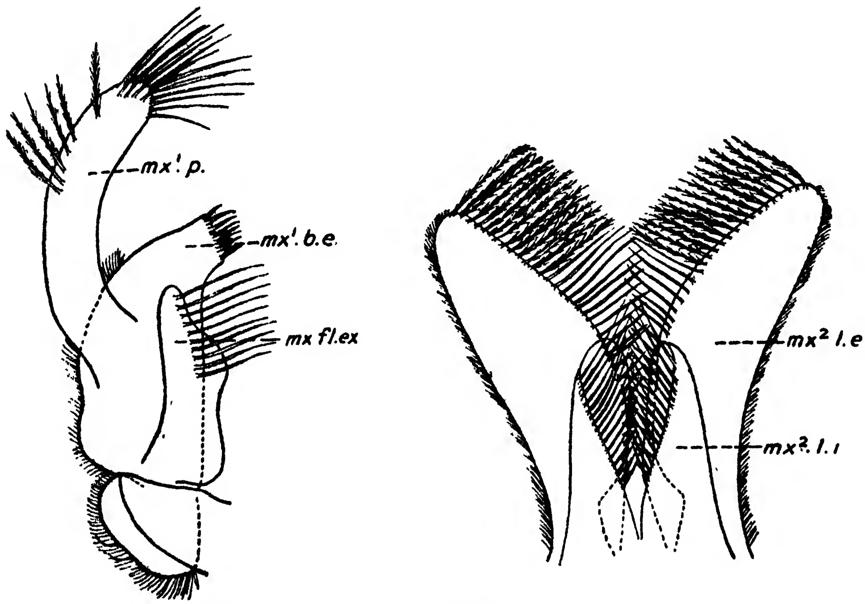
The movement of the maxillipeds is latero-medial, the parallel comb-row of setae on the second joint of the palp working over the sieve of setae on the inner margins of the maxillae, and food-particles are transferred from the maxillae to these comb-rows. The distal joint of the maxilliped-palp, bent at right-angles, is capable of being bent still further inwards so that its serrate setae pass over the comb-rows of the second joint and carry food-particles from them. The distal joint of the palp is then bent forward again and the particles removed by the maxillules, probably by the setae on the flap-shaped expansion proximal to the biting endite. Food-particles retained by the setae at the tips of the maxillary lobes are removed directly by the maxillules.

The maxillules work with a latero-medial movement, their approximation resulting in the tips of the setae of the biting endite being pushed forwards through the gap between the paragnath-processes, since the setae do not interlock to any great extent. Food-particles on these setae are removed by the setae on the incisor regions of the mandibles.

It will be remembered that the left mandible only possesses a lacinia mobilis. In this connection Cannon and Manton (1927) state that the asymmetry of the mandibles is of functional assistance in passing food to the mouth, and a description of how this takes place in *Hemimysis* is given (p. 235). It appears that food is carried up the oesophagus by a sucking action of the crop, for, on feeding a young animal on starch-particles stained with iodine, after some

time the crop may be seen through the semi-transparent chitin to become suddenly full. This has been noted by Hart (1930) in the amphipod *Corophium volutator* (Pallas). In *Haustorius*, as well as in *Corophium*, the oesophagus is short, so that it may reasonably be supposed that peristalsis of the oesophagus is not the cause of movement of the food into the crop. Since in Crustaceans, whatever their feeding-methods, the mouth-appendages do not lie inside the mouth but surround it, a sucking action up the oesophagus would carry food-particles towards the mouth from adjacent regions, and loss of stray food-particles would be decreased.

TEXT-FIG. 12.



(*Left*) The left maxillule of *Haustorius*, viewed from in front.
(*Right*) The maxillae of *Haustorius*, viewed from in front.

(4) FEEDING ON LARGE FOOD-MASSES.

Several points in the structure of the animal suggested that feeding on large food-masses might take place to some extent. The second gnathopods are chelate, but the chelae are very small and hidden in the setae of the limb. The serrate setae on the palps of the maxillipeds suggest that the maxillipeds might be used for holding masses of food. The mandibles, maxillules, and maxillipeds resemble to some extent those of a raptorial Amphipod such as *Gammarus locusta*. Accordingly several animals were starved for some days, and then placed in tubes containing pieces of boiled white of egg stained with cochineal in sea-water. After about 24 hours the cochineal could be seen through the chitin to have reached the alimentary system. Examination,

however, revealed that the cochineal was lying in the hepato-pancreatic lobes, and not in the alimentary canal.

Cussans (1904) states that 'in *Gammarus* which had been fed upon carmine for a week no granules were visible in the diverticula of the gut, though the mid-gut contained a quantity of the substance.' At any rate, the presence of cochineal in the gut-diverticula of *Haustorius* would seem to show that the animal had been feeding on the solid white of egg. No animal was ever actually observed to feed on large food-masses, but it is probable that the food is held by the maxillipeds and mandibular palps, and bitten into by the mandibles and the biting endites of the maxillules.

DISCUSSION

It has been shown that the Amphipod *Haustorius arenarius* is able to feed on small food-particles suspended in the water in the sand in which it lives. This is carried out by a filter-mechanism formed by the series of mouth-appendages, the maxillae producing and filtering an anteriorly directed current of water.

Cannon and Manton (1927) have shown that an anteriorly directed feeding-current occurs in *Hemimysis*, produced by the action of the maxilla, and it will therefore be of interest to consider how far *Haustorius* and *Hemimysis* correspond in their filter-feeding mechanisms, and what is the significance of any correspondence or divergence between the two.

In *Haustorius* the endopodite and exopodite of the maxilla have disappeared completely (text-fig. 12, *right*), and the movement of the limb in producing the feeding-current is such that it involves rotation of the limb about its own axis, while Cannon and Manton (1927) (and private communication from Professor Cannon) consider that in the Mysid the endopodite and exopodite are of paramount importance in the production of the feeding-current acting as valves; moreover, the movement of the limb resembles that of the first trunk-limb, but is more lateral (p. 229).

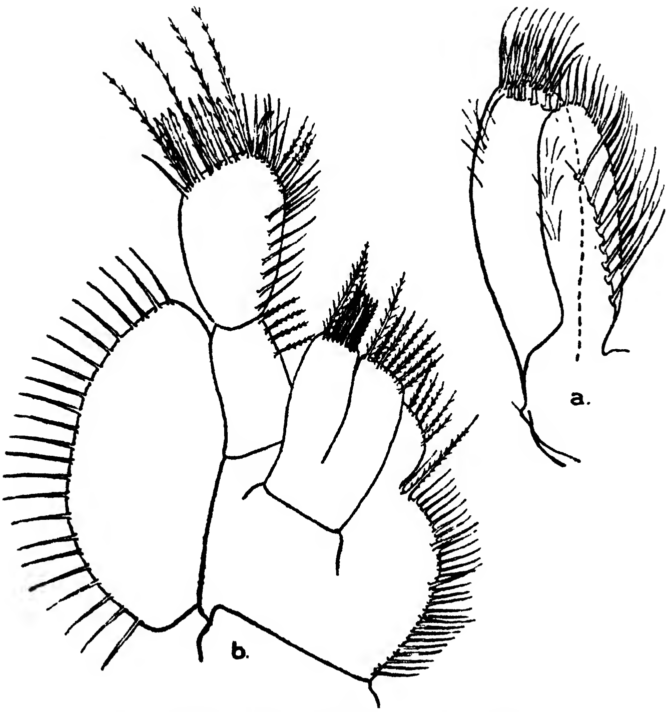
Apart also from the differences in the form and movement of the maxillae of *Haustorius* and *Hemimysis*, the two feeding-mechanisms differ in the manner in which the food-particles are removed from the filter-setae of the maxilla, and passed forward to the mouth. In *Haustorius* the second joint of the maxillipedal palp bears several "comb-rows" of setae which scrape across the maxillary filter-setae, but in *Hemimysis* food is scraped off the maxilla by the endite on the protopodite of the first thoracic limb.

Cannon and Manton have suggested that the primitive feeding-habit of the Malacostraca was filtratory, and give a diagram of the mouth-parts of a generalised Malacostracan (1929, p. 176). They point out that in the higher forms of the Syncarida, Peracarida, and Eucarida this method of feeding has been lost, and a raptorial method of feeding substituted by the suppression of the proximal regions of the mouth-parts forming the filter-mechanism, and the elaboration of the distal regions into raptorial structures. For

example, *Paranaspides* and *Anaspides* possess a filtering-mechanism, and lead on to *Koonunga* and *Bathynella*, which have lost their filtering-mechanism and feed on large masses of food. Similarly, the Mysids with both a filter-feeding mechanism and a habit of feeding on large food-masses have led on to the Amphipods or Isopods, feeding on large food-masses only.

If the filter-feeding mechanism of *Haustorius* agreed closely in both form and function with that of the generalised Malacostracan described by Cannon and Manton, it might be concluded that *Haustorius* represented a link between the Mysid with its dual feeding-habits and the typical raptorial Amphipod—that is, that *Haustorius* was primitive with respect to its feeding-mechanism.

TEXT-FIG. 13.



The maxilla of (a) *Gammarus* and (b) *Mysis*.

But a comparison between the two has clearly shown that not only structurally but functionally *Haustorius* differs completely from *Hemimysis*; and the absence of endopodite and exopodite in the maxilla of *Haustorius* is not a primitive character. In no way could the feeding-mechanism of *Haustorius* be functionally derived from that of a Mysid.

On the other hand, comparison of the mouth-appendages of *Haustorius* with those of a typical raptorial Amphipod such as *Gammarus* shows them to be very similar. In both *Haustorius* and *Gammarus* the mandibular palp

bears on the distal joint a row of closely set short setae, which no doubt serve in gripping food-particles which are being held against the mouth-parts. The maxilla of *Gammarus* consists of an inner and an outer lobe, with no endopodite or exopodite (text-fig. 13), while that of *Haustorius* represents the *Gammarus* maxilla expanded and broadened and more setose. The maxillipeds of both *Gammarus* and *Haustorius* are closely alike, with the exception that in *Haustorius* they are more setose, and in addition bear the parallel rows of comb-setae on the second joint of the palp, which are of supreme importance in removing food-particles from the maxilla.

The mouth-parts of *Haustorius* resemble those of the typical Amphipod far more than they resemble those of a Mysid (compare text-fig. 12, *right*, with text-fig. 13), and it may be concluded that *Haustorius* has developed from some more normal Amphipod. *Bathyporeia* and *Urothoe* seem to be intermediate between *Gammarus* and *Haustorius*, and are included with *Haustorius* in the Haustoriidae.

Sars suggested that many of the peculiarities of *Haustorius* were to be explained as adaptive modifications in relation to its mode of life, and possibly the filter-feeding mechanism may be similarly accounted for. As a hypothesis it may be supposed that when *Haustorius* took to burrowing the typical 'tunnel' shape of the body in cross-section developed, and the activity of the pleopods increased, producing the powerful current which enables the animal to burrow. This current must have passed in beneath the head and flowed posteriorly, due to its confinement by the coxal plates and flattened pereiopods, and must have inevitably drawn in food-masses. To deal with these the maxillae worked as in an ordinary Gammarid—that is, they were maxillipedal, simply pushing food on to the mandibles. This activity, particularly in the confined space of the 'tunnel' and surrounding sand, would have sucked food-particles between the maxillae towards the mouth, and in order to deal with these the setae developed on the inner edges of the maxillae—just as the filtratory setae developed on the inner edges of the trunk-limbs of *Nebalia*. Later, in order to produce a forwardly directed feeding-current more effectively, advantage was taken of the confined space of the 'tunnel,' and the rotatory movement of the limb was developed.

In a raptorial Amphipod the movement of the maxillipeds is almost completely latero-medial, and in *Haustorius* this has been taken advantage of to develop setae on that part of the limb which would comb the filter-setae towards the middle line—that is, on the second joint of the palp. Setae on the protopodite, as on the first thoracic limbs of *Mysis*, would be useless.

In both *Haustorius* and *Hemimysis* a forwardly directed feeding-current is produced and filtered by the maxillae, but here all resemblance between the two feeding-mechanisms ends. That of *Haustorius* is consequent on the modification of the mouth-parts of a raptorial Amphipod, with a corresponding change in their mode of functioning.

SUMMARY

(1) The distribution of the animal in Robin Hood's Bay, Yorkshire, is probably connected with the amount of water and organic material in the sand, influenced by the formation of the scar system.

(2) The animal swims on its back by the beating of the powerful pleopods, the metachronial rhythm of which increases their efficiency.

(3) When swimming the animal is positively phototropic, and negatively phototropic when burrowing.

(4) Burrowing is a modification of the swimming movements, and is dependent on the expulsive action of the swimming current.

(5) The mouth-parts, with the exception of the maxillae and the maxillipeds, bear a strong resemblance to those of *Gammarus locusta*.

(6) The animal shows two feeding-methods, one filtratory and the other the more usual Amphipod type of feeding on large food-masses. In filter-feeding the maxilla functions as a pump producing a feeding-current and also as a sieve-plate. Particles collected on the maxillae are removed by the maxillipeds, passed to the maxillules, and so to the mandibles and mouth-opening.

(7) The resemblances of *Haustorius* to a Mysid in its filter-feeding mechanism are homoplastic rather than homologous, since the maxilla is entirely devoid of endopodite and exopodite, which play essential parts in the Mysid feeding mechanism. *Haustorius* feeds by means of a rotation of the maxilla on its own axis, differing from the movement of the maxilla of Mysis. The filtratory mechanism of *Haustorius* is probably therefore, a secondary development from the raptorial method of other more normal Amphipods.

REFERENCES.

(1) Blegvad, H. 1922. On the Biology of some Danish Gammarids and Mysids. Repts. Dan. Biol. Stn., Copenhagen, vol. xxvii.

(2) Bruce, J. R. 1928. The Physical Factors of the Sandy Beach. Journ. Mar. Biol. Association, vol. xv. no. 2.

(3) Cannon, H. G., & Manton, S. M. 1927. On the Feeding Mechanism of a Mysid Crustacean, *Hemimysis lamornae*. Trans. Roy. Soc. Edin. vol. lv. pt. 1.

(4) Cannon, H. G. 1927. On the Feeding Mechanism of *Nebalia bipes*. Trans. Roy. Soc. Edin. vol. lv. pt. 2.

(5) —— 1928. On the Feeding Mechanism of the Fairy Shrimp, *Chirocephalus diaphanus* Prévost. Trans. Roy. Soc. Edin. vol. lv. pt. 3.

(6) Cannon, H. G., & Manton, S. M. 1929. On the Feeding Mechanism of the Syncarid Crustacea. Trans. Roy. Soc. Edin. vol. lvi. pt. 1.

(7) Chevreux, E., & Fage, L. 1925. Faune de France: Amphipodes.

(8) Cussans, M. 1904. *Gammarus*. L. M. B. C. Memoirs, xii.

(9) Hart, T. J. 1930. Preliminary Notes on the Bionomics of the Amphipod *Corophium volutator* Pallas. Journ. Mar. Biol. Association, vol. xvi. no. 3.

(10) Hunt, O. D. 1925. The Food of the Bottom Fauna of the Plymouth Fishing Grounds. Journ. Mar. Biol. Association, vol. xiii. no. 3.

(11) Manton, S. M. 1928. On some Points in the Anatomy and Habits of the Lophogastrid Crustacea. Trans. Roy. Soc. Edin. vol. lvi. pt. 1.

(12) Sars, G. O. 1895. An Account of the Crustacea of Norway, vol. i. Amphipoda. Christiania and Copenhagen.

(13) Scott, A. 1922. The Food of Young Plaice (*Pleuronectes platessa*). Journ. Mar. Biol. Association, vol. xii. no. 4.

(14) Stebbing, T. R. 1906. Amphipoda.—I. Gammaridea. Das Tierreich, Leif. xxi.

Abbreviations used in the text-figures.

a^1. = antennule.
cr. = crop.
f.b. = food-basin.
l. = labrum.
md. = mandible.
md.i. = incisor region of the mandible.
md.m. = molar region of the mandible.
md.p. = palp of the mandible.
md.p.c.r. = comb-row of setae on the palp of the mandible.
mx^1.b.e. = biting endite of the maxillule.
mx^1. = the maxillule.
mx^1.fl.ex. = flap-shaped expansion of the maxillule.
mx^1.p. = palp of the maxillule.
mx^2. = the maxilla.
mx^2.l.e. = external lobe of the maxilla.
mx^2.l.i. = internal lobe of the maxilla.
mxpd. = the maxilliped.
mxpd.c.r. = the comb-rows of setae on the maxilliped.
mxpd.e^1. = first endite of the maxilliped.
mxpd.e^2. = second endite of the maxilliped.
mxpd.p. = palp of the maxilliped.
oes. = oesophagus.
p. = paragnath.
p.r. = paragnath-ridge.
tr. = triturator.

Revision of the genus *Lucilia* R.-D. (Diptera, Calliphoridae).

By D. AUBERTIN, M.Sc., F.L.S.

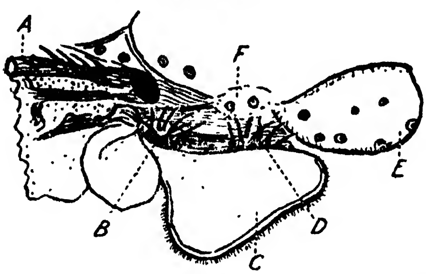
(With 30 Text-figures)

[Read 11 May 1933]

INTRODUCTION.

The genus *Lucilia* is well in accord with the characters of the subfamily Calliphorinae, but is distinguishable from genera somewhat similar in appearance by the bare stem-vein (text-fig. 2), setae on a considerable part of the upper and under side of the third wing-vein, bare squama, presence of parasquamal and tympanic tufts of hair (text-fig. 1), absence of long hair on the metathoracic supraspiracular convexity, and presence of three pairs of postsutural dorso-central bristles.

TEXT-FIG. 1.



A, costa ; B, tympanic tuft ; C, squama, × 14 ; D, parasquamal tuft ; E, scutellum ; F, post-alar callus.

All the species of flies, commonly called green-bottles, included in this genus bear a very close superficial resemblance to one another ; consequently many of them have been described over and over again by early writers, who relied largely on slight variations in the metallic colouring for the separation of species. The discovery of good taxonomic characters is of recent occurrence, and only those species occurring in Europe and N. America have been revised in accordance with them. The flies have the habits of blow-flies, and must therefore be regarded as potential disease-carriers, while two species are also of considerable economic importance in S. Africa and Australia, in connection with the blowing of wool.

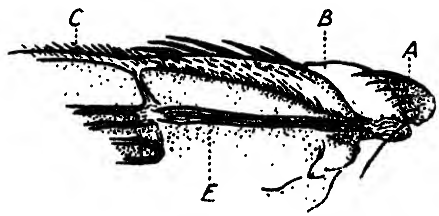
On account of the economic importance of the group, a revision of the genus, based on an examination of material from all over the world, and a critical study of as many types as possible will, it is hoped, be of value.

My thanks are due to Monsieur Séguy, Dr. Zerny, Dr. van Emden, Dr. Enderlein, and Mr. Wainwright for the loan of material and permission to examine types in their charge, and I have also to acknowledge with much gratitude the help and advice accorded me by Dr. J. M. Aldrich, of the Smithsonian Institution, Washington, D.C. All figures, except the first three, have been drawn by Miss B. Hopkins.

History of the genus.

Prior to 1830 a number of species of *Lucilia* were described under the generic term *Musca* by Wiedemann (1830) and Meigen (1826), the latter author placing all the metallic forms in his group '*Muscae nobiles*'. Robineau-Desvoidy (1830) established the genus *Lucilia*, but the characters cited by him for distinguishing the group from *Phormia*, on the one hand, and *Chrysomyia*, on the

Text-fig. 2.



Base of wing from dorsal surface, × 26. A, epaulette; B, basicostal scale; C, costa; E, stem-vein.

other, cannot be regarded as of great taxonomic value. He included thirty-seven species in the genus, of which all except one, *L. caesar* (L.), were described as new. The types of many of these species are no longer extant, but from those which have been examined it is evident that the majority belong either to *Lucilia* or *Orthellia*, as understood at the present time.

Macquart uses the term *Lucilia* in rather a wide sense, including *Phormia*, *Chrysomyia*, and *Pyrellia* as subsidiary groups; he refers (1835) to *Musca caesar* L. as the type of the genus, a satisfactory and valid designation of the genotype.

Bigot in his earlier papers described a heterogeneous collection of species under *Lucilia*, but later followed Rondani in the use of *Somomyia*, a conception which covered *Calliphora* and *Phormia* as well. van der Wulp, in his catalogue (1896), lists all oriental species originally described under *Somomyia* and *Compsomyia*, under *Lucilia*. Brauer and von Bergenstamm (1889) place the genus near *Musca*, but do not distinguish between *Lucilia*, *Orthellia*, and *Phormia*. Girschner's work (1893) made it possible to separate off *Orthellia*,

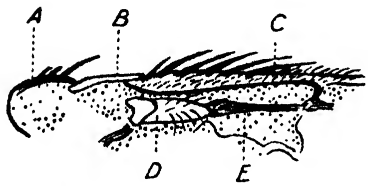
and Hough (1899) laid the foundations of the modern conception of the genus by stressing the importance of chaetotaxy.

Kramer (1911) drew attention to the value of the male genitalia for diagnostic purposes, Shannon (1924) pointed out that the basicosta and subcostal sclerite (text-figs. 2 & 3) afford useful characters for subdividing the group, and Malloch (1926) recognized definite segregates which he considered to be of subgeneric and generic value. One of these segregates, *Hemipyrellia*, has recently been revised (Aubertin, 1931).

As reliable diagnostic characters became known, attempts were made to deal with the species in various parts of the world. The European forms have been worked out thoroughly by Stein (1924), Richards (1926), Collin (1926), and Séguy (1928), while the North and South American forms have been dealt with by Shannon (1926).

After examination of material from nearly all parts of the world, I am able to recognize twenty-seven good species, two of which have clearly recognizable varieties. From an examination of types and study of the literature, eighty-two

TEXT-FIG. 3.



Base of wing from ventral surface, × 26. A, epaulette ; B, basicostal scale ; C, costa ; D, subcostal sclerite ; E, stem-vein.

names have been listed as synonyms under the appropriate species, and a list of names which have at one time or another been referred to the genus *Lucilia*, together with any relevant information, is appended. An attempt has been made to render this list as complete as possible by including both new and established synonymy, so that it may be of value for reference, but it is probable that there are omissions.

SYNONYMY.

The new synonymy recorded in this paper has been determined, so far as possible, from an examination of the original types, and the names of all types examined have been marked with an asterisk. Incidentally much synonymy published by other authors has been confirmed, and that which is involved and erroneous is discussed. The synonymy published in Bezzi's 'Palaearctic Catalogue' is not included, and is only referred to where the author is in disagreement with it. The synonymy in Aldrich's 'Catalogue of North American Diptera' is based mainly on Hough's conclusions, many of which are unreliable. The author is not entirely in agreement with the synonymy of the oriental species established by Patton, and an attempt has been made to elucidate it.

Subgenera.

Certain species and groups of species within the genus have been ranked as subgenera by Malloch and Shannon. The latter writer at first gave generic rank to *Francilia* (1924), but later (1926) reduced it to a subgenus, the distinguishing characters being the absence of the presutural intra-alar bristle and the basal thickening of the short plumose arista. Shannon (1926) also erected the subgenus *Viridinsula* for Walker's species *pionia* from Galapagos, on account of the peculiar downward projection of the face and epistome. Malloch (1926) placed his species *fumicosta* in the subgenus *Luciliella* on account of the presence of minute bristles on the upper half of the parafacials, and has recognized the group with a bright yellow basicostal scale, bare subcostal sclerite, and three postsutural acrostichal bristles, of which *L. sericata* is typical, as worthy of subgeneric rank under the name *Phaenicia* R.-D. He refers *L. infernalis* (Vill.) (*L. nigricosta* Mall.) to *Lucilia*, sens. str., of which he considers *L. caesar* to be typical.

An attempt has been made by Rohdendorf (1928) to divide the group into genera and subgenera on characters found in the penis. His work is based on European species only, and results in the separation of forms which on other characters appear to be closely allied. The characters found in the penis in this genus can, in my opinion, only be regarded as of use in the separation of species.

It is apparent from this review that there are certain groups within the genus which might very well be given subgeneric rank, but one is then faced with the alternative either of keeping a heterogeneous residue under the term *Lucilia*, sens. str., or of making further subgenera for which one can find no really satisfactory diagnostic characters. To obviate this difficulty, I prefer to omit the subgenera, although using the characters for subdividing the genus into major groups, to which, however, no definite taxonomic value is assigned.

Taxonomic characters.

The characters used, either singly or in combination, for the distinction of groups within the genus are the colour of the basicostal scale, presence or absence of hairs on the subcostal sclerite, and presence or absence of minute hairs on the parafacials. Further characters which serve for the distinction of species within the groups are the infuscation of the wing-border, the thoracic chaetotaxy, the distance between the eyes in the male, and the shape of the male genitalia. The two last are secondary sexual characters and are therefore useless for the determination of female specimens. These can always be assigned to a group, and in the majority of cases to a species, but the females of, for instance, *L. caesar*, *L. ampullacea*, and *L. illustris* cannot at present be distinguished from one another with certainty, when taken without the males. This difficulty will probably be overcome when bred series of each species are available for examination. The body-colour, which figures so extensively in the older descriptions, is quite useless for the purpose of specific distinction, as it is subject

to extreme variation, and a dead specimen which appears to be purple may become green when subjected to a moist atmosphere. The colour of the antennæ is also very variable, and can only carry weight when used in conjunction with a number of other characters.

Biology.

According to Séguy (1928) the adults feed on flower-juices, carrion, and faeces; the females are oviparous.

A good deal is known about larval development in this group. The maggots of the majority of species probably develop in decaying animal matter, but some of them have acquired specialized ways of living. *L. sericata* and *L. cuprina* are notorious for their habit of blowing wool; the eggs are laid on living sheep in the soiled wool, on which the maggots feed, and then either make sores or burrow into those already present, feeding on the flesh and discharges; as a result of this attack the quality of the wool is impaired, much of it being rendered useless, the health of the sheep becomes poor, and many of them die. A good account of wool-blowing and methods of control in South Africa is given by Smit (1929), although he does not distinguish between the two species *L. sericata* and *L. cuprina*. He estimates that the loss in revenue to the sheep-farmers, on account of the activities of blow-flies, amounted in 1924 to over £78,000. Damage on a similar scale occurs in Australia and New Zealand, and an account of it in the former country has been published by Froggatt (1922).

L. bufonivora is a specific parasite of toads, and there are indications that it may occasionally attack other Amphibia. Stadler (1930) deals with the development of the maggots, and gives a summary of the more important papers on the subject. This species has frequently been identified as *L. silvarum* Mg., but the validity of the two species is now generally accepted.

Hesse (1908) observed a female *Lucilia* ovipositing on a fledgling missel-thrush that had fallen out of its nest, but was still alive. The fly was identified by Girschner as *L. caesar*. Portchinsky (1885) found that *L. caesar* bred mainly in carrion. Howard (1900), an American writer, recorded *L. caesar* as breeding in human excrement, but this record probably refers to *L. illustris* (Mg.) †, as *L. caesar* (L.) does not occur in N. America. The maggots of various species, particularly *L. sericata* and *L. cuprina*, have been taken from sores on man and animals.

The life-history of *L. sericata* and the effect of external factors on its development have been studied by Bishop and Laake (1915), Herms (1928), and Holdaway (1930), while Herms (1907) has also studied the development of *L. illustris* (Mg.) under the name *L. caesar* (L.).

Species of the genus *Lucilia* are subject to the attack of two hymenopterous parasites: *Alysia manducator* Panz. attacks the pupa, while *Nansonia brevicornis* Ashm. is a parasite of the maggot (Séguy, 1928).

† There is a series of *L. illustris* Mg. in the Paris Museum, bred from maggots taken in a bird's nest, where they were probably feeding on débris.

Geographical distribution.

The genus is represented all over the world, but only one or two species have attained to a world-wide distribution. *L. sericata*, predominantly a Palaearctic species, is now more or less cosmopolitan, and *L. cuprina*, an Ethiopian species, has become widely spread in tropical and subtropical regions; both these species undoubtedly owe their wide distribution to the agency of man, and their connection with the sheep-farming industry. Apart from these two species, North, Central, and South America have each their characteristic groups of species, as have also the combined Oriental and Australian regions, and the Palaearctic region. The Nearctic and Palaearctic Regions have three species in common—*L. illustris*, *L. silvarum*, and *L. bufonivora*. Of the Palaearctic species, *L. illustris*, *L. caesar*, and *L. silvarum* seem to be the most widely spread, reaching across Europe, Siberia, and China to Japan. Since, however, the European fauna has been studied very much more intensively than that of Central and Northern Asia, it is probable that species known only from Europe will eventually prove to be more widespread. *L. papuensis* and *L. porphyrina* are characteristic of the Oriental, Australian, and Eastern Palaearctic Regions. One somewhat aberrant species, *L. graphita* Snn., appears to be confined to the Hawaiian Islands, while *L. pionia* (Walk.) is endemic in Galapagos, and *L. alaskensis* has so far been recorded only from Alaska.

The species confined to South America appear to be much more closely related to one another than is the case in any of the other big zoo-geographical units, and are, on the whole, extremely difficult to separate out into species comparable in status with those found in other parts of the world. Most of the characters which can be used diagnostically are rather variable in each species, as, for instance, the distance between the eyes in the male, the colour of the tomentum on the face, the degree to which the wings are infuscated at their bases, and the colour of the squama in both males and females; the male genitalia, however, are singularly uniform in appearance throughout all the South American species, and show only slight and intangible differences in the shape and length of the median forceps and in the degree of hairiness.

The most easily recognized species is *L. purpurascens* (Walk.); the specimens are generally large, the eyes holoptic with the anterior facets markedly enlarged, the face reddish grey, the wings often infuscated basally, and the squamae dark brown. This species is well represented in Central America, and I have also seen specimens from Brazil. The commonest species, distributed all over the southern continent, is *L. eximia* (Wied.); it is characterized by the golden colour of the facial tomentum, light brown to orange antennae, squamae brown in the male and white in the female, and the eyes in the male separated by a distance equal to the width of the third antennal segment. *L. ochricornis* (Wied.), common in the southern part of the continent, may be separated from *L. eximia* by the greyish-red colour of the face, the deeply infuscated squamae in both sexes, and the strong development of the chaetotaxy. *L. rica*

may be distinguished from *L. eximia* (Wied.) by the closely approximated eyes in the male and the silvery facial tomentum †. It is found mainly in the West Indian Islands and in Central America. *L. rica* is evidently closely related to *L. ibis* Snn., described from specimens taken in Peru ; but this latter species (of which I have seen no authentic specimens) appears to be characterized by the basal infuscation of the wings and the very dark brown colour of the squamae in both sexes. *L. ibis* should be distinguishable from *L. purpurascens* (Walk.) by the contrasting genitalia, those of the latter species being comparatively small and bare.

Genus LUCILIA.

Robineau-Desvoidy, 'Essai sur les Myodaires,' p. 452 (1830).
Somomyia Rond., *part.*, Dipt. Ital. Prod. iv, p. 9 (1861).
Phaenicia R.-D., Posth. ii, p. 750, xxx (1863).
Phumonesia Vill., Bull. Soc Ent. Fr., p. 307 (1914).
Bufolucilia Tns., Proc. U.S. Nat. Mus. lvi, p. 542 (1919).
Francilia Snn., Insec. Inscit. Mens. xii, p. 74 (1924).
Argoracrites Ség., Bull. Soc. Path. Exot. xviii, p. 734 (1925), *nom. nud.*
Caesariceps Rohd., Rev. Zool. Russe, iv, fasc. 1 (1925). (Entom. Mitt. xvii, p. 337 (1928).)
Dasylucilia Rohd., Rev. Zool. Russe, iv, fasc. 1 (1925). (Entom. Mitt. xvii, p. 338 (1928).)
Roubaudiella Ség., Bull. Soc. Path. Exot. xviii, p. 735 (1925).
Luciliella Mall., Ann. & Mag. Nat. Hist. (9) xvii, p. 507 (1926).
Viridinsula Snn., Proc. Ent. Soc. Wash. xxviii, p. 131 (1926).

Genotype *L. caesar* (L.).

Metallic-coloured Calliphorine flies of medium size.

Head. Eyes bare ; parafrontals and parafacials covered with silver or golden tomentum ; arista long-plumose ; jowls one-third of eye-height ; vibrissae ascend almost halfway up facilia but are inconspicuous.

Thorax. Chaetotaxy as follows : humerals 3–*4* ‡, notopleurals *2*, supra-alars *2*+*3*–4 §, intra-alars 2–*3*+*2*–3, postalars *2*–3, dorso-centrals *3*+*3*, acrostichals *2*–3+*2*–*3*, marginal scutellars *4*.

Abdomen. Second abdominal segment with or without marginal macrochaetae ; discal macrochaetae on last segment only.

Wings. Third longitudinal vein bristly both above and below, as far as small cross-vein ; squama bare ; postalar and tympanic tufts present.

Legs. Brown to black ; middle tibia usually with one, sometimes with two or three antero-dorsal bristles.

† Both these characters are relative, and I should be inclined to regard *L. rica* as a race of *L. eximia*, were it not that the latter overruns the geographical range of the former.

‡ Italic figures indicate the more usual number of bristles where there is any variation.

§ The posthumeral bristles are here treated as presutural supra- and intra-alar bristles.

Key to species of Lucilia.

1. Arista short-plumose, thickened at the base; presutural intra-alar bristle absent .... *L. alaskensis* (Snn.). (N. America.)
   Arista long-plumose; presutural intra-alar bristle present .... 2.
2. Face produced markedly downwards and forwards as in text-fig. 4 .... *L. pionia* (Walk.). (Galapagos Is.)
   Face not produced as in text-fig. 4 .... 3.
3. Parafacials bearing a row of minute bristles; anterior margin of wing infuscated .... *L. fumicosta* Mall. (Philippine Is.)
   Parafacials bare .... 4.
4. Subcostal sclerite with one or more wiry upstanding bristles .... 5.
   Subcostal sclerite with fine decumbent pubescence.. 13.
5. Anterior margin of wing deeply infuscated .... 6.
   Wing hyaline or slightly infuscated at base and along the costa .... 7.
6. In male, antennae orange, upper lobe of squama white; three postsutural acrostichal bristles .... *L. infernalis* (Vill.). (Ethiopian Region.)
   In male, antennae dark brown, upper lobe of squama more or less infuscated; two postsutural acrostichal bristles .... *L. infernalis* var. *caerulia* (Ség.). ((Ethiopian Region.)
7. Dark shining blue-black species; three postsutural acrostichal bristles .... *L. graphita* Snn. (Hawaiian Is.)
   Metallic green, blue, or purple species; two postsutural acrostichal bristles .... 8.
8. Hypopygium shining green, rather prominent; male genitalia as in text-fig. 6 .... *L. caesar* (L.). (Palaearctic Region.)
   Hypopygium inconspicuous or invisible .... 9.
9. Anterior pair of postsutural acrostichal bristles more advanced than second pair of postsutural dorsocentral bristles .... 10.
   Postsutural acrostichal bristles level with, or slightly posterior to, second pair of postsutural dorsocentral bristles .... 9 *a*.

9 *a*. Very large flies; eyes in male holoptic; jowls rounding; male genitalia as in text-fig. 13 .... *L. sinensis*, sp. n. (China.)
   Smaller flies; eyes in male closely approximated, but not holoptic; jowls more angular; genitalia as in text-fig. 11; in male one, in female two antero-dorsal bristles to middle tibia .... *L. papuensis* Macq. (Eastern Palaearctic, Oriental, and Australian regions.)

10. Eyes in male closely contiguous for some distance .. 11.
    Eyes in male closely contiguous at one point, but distance between them widening rapidly below this point; male genitalia as in text-fig. 7 .... *L. illustris* (Mg.). (Palaearctic and Nearctic Regions.)
11. Squama pure white; wings somewhat yellowish; male genitalia as in text-fig. 8 .... *L. ampullacea* Vill. (Palaearctic Region.)
    Squama generally infuscated, at least in male .... 12.
12. Antennae dark brown .... *L. porphyrina* (Walk.). (Eastern Palaearctic and Oriental Regions.)

Antennae orange .... *L. porphyrina* var. *flavicornis* [Mall. (Australian Region.)

13. Basicostal scale clear yellow .... 14.
Basicostal scale deep orange, black, or brown ..... 20.

14. Abdomen with a row of upstanding marginal macrochaetae on second visible segment .... 15.
Abdomen with no obvious macrochaetae on second visible segment of abdomen .... 16.

15. Distance between eyes, in male, at least three times as great as width of third antennal segment; middle tibia with two antero-dorsal bristles ...... *L. regalis* (Mg.). (Palaearctic [Region.)
Distance between eyes, in male, less than width of third antennal segment; middle tibia with only one antero-dorsal bristle .... *L. thatuna* Snn. (Nearctic [Region.)

16. Thorax with two postsutural acrostichal bristles.... 16 *a*.
Thorax with three postsutural acrostichal bristles... 17.

16 *a*. Distance between eyes, in male, two and a half to three times width of third antennal segment; thorax grey-dusted between the humeri ...... *L. clavia* (Walk.). (Nearctic [Region.)
Eyes in male closely approximated; area between the humeri not grey-dusted .... *L. caeruleiviridis* Macq. (Ne- [arctic Region.)

17. Middle tibia with two or three antero-dorsal bristles. 18.
Middle tibia with one antero-dorsal bristle......... 19.

18. Distance between eyes, in male, equal to length of third antennal segment; sternites of male with tufts of bristles .... *L. pilosiventris* Kram. (Palae- [arctic Region.)
Distance between eyes, in male, equal to width of third antennal segment; sternites in male without conspicuous tufts of bristles .... *L. richardsi* Coll. (Palaearctic [Region.)

19. Abdomen of male somewhat arched in profile, the sternites bearing tufts of long hairs, male hypopygium rather prominent; parafrontals of female usually bare, apart from frontal and fronto-orbital bristles .... *L. cuprina* (Wied.). (Palaearctic, [Ethiopian, Oriental, Australian, Nearctic, and Neotropical Regions.)
Abdomen of male more or less oval; sternites without tufts of hairs; male hypopygium inconspicuous; parafrontals in female with short, fine, decumbent stiff hairs among the frontal and fronto-orbital bristles .... *L. sericata* (Mg.). (Palaearctic, [Ethiopian, Oriental, Australian, Nearctic, and Neotropical Regions.)

20. Abdomen with well-developed macrochaetae on second visible segment .... 21.
Abdomen without upstanding marginal macrochaetae (if any are present they are fine and closely appressed)........................... 22.

21. Three postsutural acrostichal bristles .... *L. silvarum* (Mg.). (Palaearctic [and Nearctic Regions.)
Two postsutural acrostichals bristles .... *L. bufonivora* Mon. (Palaearctic [and Nearctic Regions.)

22. Pubescence on subcostal sclerite golden-yellow, eyes in male almost touching; squama white .... *L. caeruleiviridis* Macq. (Ne- [arctic Region.)
Pubescence on subcostal sclerite brown .... 23.

23. Eyes in male holoptic, anterior facets enlarged; wings more or less infuscated at base; parafacials reddish, covered with sparse grey tomentum	*L. purpurascens* (Walk.). (Neotropical Region.)
Eyes in male not holoptic, though sometimes closely approximated; anterior eye-facets not markedly enlarged	24.
24. Facial tomentum more or less golden; eyes in male separated by width of third antennal segment; antennae brownish orange, or entirely orange; squama brown in male, white in female	*L. eximia* (Wied.). (Nearctic and Neotropical Regions.)
Facial tomentum reddish grey or silver	25.
25. Eyes in male separated by distance equal to width or half width of third antennal segment	26.
Eyes in male more closely approximated	27.
26. Eyes in male separated by width of third antennal segment; squama white in both sexes; facial tomentum grey-silver; frons in male reduced to a fine line, but not completely obliterated; male genitalia as in text-fig. 28	*L. mexicana* Macq. (Nearctic Region.)
Squama dark brown in both sexes; eyes in male separated by distance equal to from half to almost width of 3rd antennal segment; antennae deep orange to dark brown	*L. ochricornis* (Wied.). (Neotropical Region.
27. Facial tomentum grey, very sparse, parafacials reddish-tinged; parafrontals in male reduced to a fine line; squama in both sexes dark brown	*L. ibis* Snn. (Neotropical Region.)
Facial tomentum silver-grey; eyes in male more or less holoptic; squama light brown in male, dirty white in female	*L. rica* Snn. (West Indies.)

LUCILIA ALASKENSIS (Snn.).

Francilia alaskensis Snn., Insec. Inscit. Mens. xii, p. 74 (1924).

Distribution. Alaska.

'Head somewhat higher than broad. Front and face black, overlaid with silvery pruinescence. Front narrowed, its width at narrowest point slightly less than distance between oral vibrissae. Frontal vitta (in male) slightly broader than parafrontal; parafrontal about one-half width of parafacial. Antennae black; arista longer than third joint. Beard black. Palpi yellow with scattered setae. Legs black. Wings slightly darkened; squamae white. Costal spine at tip of auxillary vein easily apparent. Postmargin of second tergite with long appressed bristles, extending nearly across third tergite. Hypopygium ventral in position, prominent; lobes of fifth sternite well developed, rather broadly ligulate with rather sparse black hairs.'

Shannon erected the genus *Francilia* for this species, but in a later paper reduced *Francilia* to the rank of a subgenus of *Lucilia*. He segregates it on account of the short-haired arista, lack of presutural bristle, additional intra-alar bristle, and position of the tympanic tuft of hairs (text-fig. 1, B) on margin of pit.

I have not seen a male of this species, and therefore insert Shannon's description as it stands. In a female identified by Aldrich, the third segment of the antenna is noticeably long and broad, the distance between the eyes at the vertex equals about one-third the width of head, and the palpi are brownish; basicostal scale black, subcostal sclerite brown, with minute decumbent black bristles; middle tibia with one antero-dorsal bristle. In this particular specimen there are only two intra-alars as in the other species of *Lucilia*.

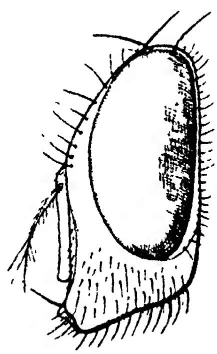
LUCILIA PIONIA (Walk.).

**Musca pionia* Walk., List Dipt. Brit. Mus. iv, p. 880 (1849).

Distribution. Galapagos Is.

♂.—*Head.* Eyes at point of closest approximation separated by a distance equal to twice or two and a half times width of third antennal segment; frons

TEXT-FIG. 4.



Head of *Lucilia pionia*, × 18.

twice width of one parafrontal, scarcely widening at either end; parafrontals with very fine hairs outside the frontal bristles; epistome and jowls produced forwards and downwards (text-fig. 4); parafacials covered with silver tomentum; antennae dark brown; palpi yellow.

Thorax. Shining blue green; two postsutural acrostichal bristles.

Abdomen. (Missing in unique specimen.)

Wings. Hyaline; basicostal scale brown; subcostal sclerite covered with soft tawny pubescence.

Legs. Brownish black; middle tibia with one antero-dorsal bristle.

Shannon (1926) erected the subgenus *Viridinsula* for this species.

LUCILIA FUMICOSTA Mall.

Lucilia (*Luciliella*) *fumicosta* Mall., Ann. & Mag. Nat. Hist. (9) xvii, p. 507 (1926).
Lucilia ditissima Bezzi, *nec* Walk., Bull. Ent. Res. xvii, p. 238 (1927).

Distribution. Philippine Is.

♂♀.—*Head.* Eyes at point of closest approximation separated by a distance

equal to half width of third antennal segment in male, in female distance equal to one-quarter width of head; parafrontals narrowed above, contiguous for a short space, with very fine hairs outside the frontal bristles, these hairs continued down on to the parafacials in an irregular line; antennae dark brown, rufous at base; palpi yellow.

Thorax. Shining green, two postsutural acrostichals.

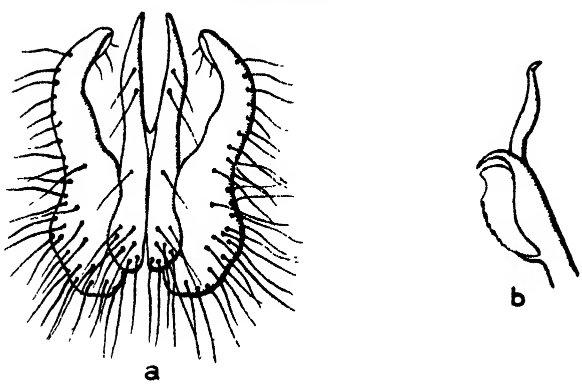
Abdomen. Shining green, the posterior margins of the second and third abdominal segments sometimes dark-margined; male genitalia as in text-fig. 5; hypopygium inconspicuous.

Wings. Infuscated along the anterior border, the colour fading away towards the posterior border which is almost hyaline; basicostal scale dark brown to black; subcostal sclerite with a few stiff upstanding brown hairs; squama brown.

Legs. Dark brown; middle tibia with two antero-dorsal bristles in both sexes.

Bezzi (1927) suggests that this species is the same as **Musca ditissima* Walk., but the type of this latter species belongs to the subfamily Rhiniinae.

TEXT-FIG. 5.



Genitalia of *Lucilia fumicosta*, × 90.

a, forceps, dorsal view; *b*, penis, lateral view.

LUCILIA CAESAR (L.).

Musca caesar L., Syst. Nat. Edn. x, p. 595 (1758).
**Musca splendida* Meig., S.B. v, p. 56 (1826).
Lucilia angustifrons Tns., Smiths. Misc. Coll. Wash. li, p. 120 (1908).
**Somomyia jeddensis* Big., Ann. Soc. Ent. Fr. (5) vii, p. 255 (1877).

Distribution.—Europe, Morocco, Manchuria, China, Japan.

♂♀.—*Head.* Frons in male entirely obliterated, parafrontals reduced to a fine line, in female eyes separated by rather more than one-quarter total head-width, frons black, two and a half times width of one parafrontal; palpi yellow; facial tomentum silver, antennae dark brownish black.

Thorax. Shining green; two postsutural acrostichal bristles.

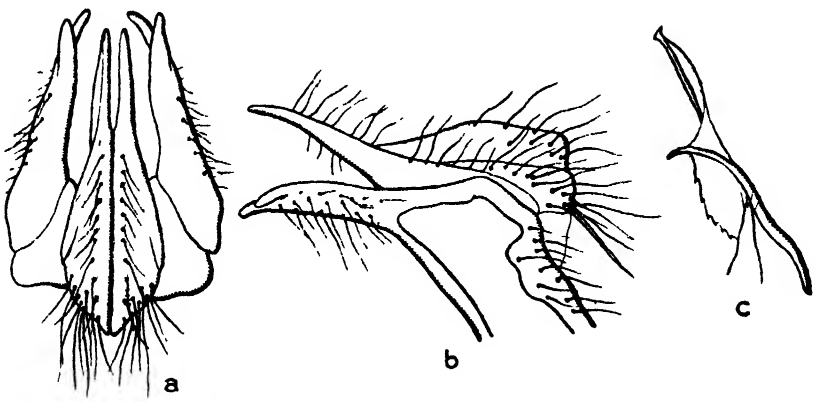
Wings. Hyaline; basicostal scale black; subcostal sclerite with short wiry black hairs; squama white.

Legs. Middle tibia with one antero-dorsal bristle.

Abdomen. First visible segment greenish black; second segment without marginal macrochaetae; sternites not abnormally hairy; hypopygium shining green and very prominent, claspers heavily chitinized, the external forceps with a characteristic double point at the extremities (text-fig. 6).

L. caesar has generally been considered to be a species with a very wide distribution, and the name has been applied at one time or another to almost every species with closely approximated eyes, in all parts of the world, the name having been wrongly used in North and South America, Australia, and New Zealand. Malloch (1927) has suggested that the range of the species is not so great as was previously imagined, and I am in full agreement with him. The species is essentially Palaearctic, being well established in Europe, the Mediterranean Islands, and Morocco; I have seen one male and possibly one female from Japan, and it is probable that it will be found in Siberia.

TEXT-FIG. 6.



Genitalia of *Lucilia caesar*, × 56.

a, forceps, dorsal view; *b*, forceps, lateral view; *c*, penis, lateral view.

L. angustifrons Tns. was synonymized by Tothill (1913), who noted that the type-specimen was abnormal in having three pairs of postsutural acrostichal bristles, a variation not infrequently met with †.

Lucilia splendida (Mg.) is regarded as a synonym of *L. silvarum* in the 'Palaearctic Catalogue', but Collin (1926) suggested that the types were really representatives of *L. caesar*. On examining them, I found that the male was certainly *L. caesar* and the female unrecognizable; in his description, Meigen states that the palpi are black, but this is an error.

† From a drawing of the male genitalia supplied by Dr. Aldrich, I am able to confirm this synonymy; it is probable, however, that Tothill was under the impression that it was the common North American species, *L. illustris* Mg.

LUCILIA ILLUSTRIS (Mg.).

Musca illustris Mg., S.B. v, p. 54 (1826).
**Musca parvula* Mg., S.B. v, p. 55 (1826).
Musca equestris Mg., S.B. v, p. 57 (1826).
**Musca muralis* Walk., List. Dipt. Brit. Mus. iv, p. 888 (1849).
Calliphora simulatrix Pand., Rev. Entom. xv, p. 218 (1896).
Lucilia caesar Howard, *nec* L., Proc. Wash. Ac. ii, p. 563 (1900).
Lucilia purpurea Tns., Smiths. Misc. Coll. li, p. 122 (1908).
Lucilia caesar Hough, *nec* L., Zool. Bull. ii, p. 288 (1899).
Lucilia caesar Tothill, *nec* L., Ann. Ent. Soc. Amer. vi, p. 248 (1913).
Lucilia caesar Johnson, *nec* L., Ann. Ent. Soc. Amer. vi, p. 242 (1913).
Lucilia caesar Snn., *nec* L., Insec. Inscit. Mens. xii, p. 75 (1924); Proc. Ent. Soc. Wash. xxviii, p. 130 (1926).
Lucilia caesar M. T. Townsend, *nec* L., Ann. Ent. Soc. Amer. xxi, p. 121 (1928).
? *Lucilia consobrina* Macq., Mem. Soc. Sci. Agric. Arts Lille, p. 217 (1848); Dipt. Exot. Suppl. iii, p. 57 (1848).
? *Lucilia fraterna* Macq., *ibid.*
? *Lucilia lepida* R.-D., Myod., p. 453 (1830).

Distribution.—Europe, N. America, Shanghai, Manchuria, Japan.

♂♀.—*Head.* Frons in male usually obliterated for a short space, eyes separated by a little less than width of third antennal segment, frontal bristles small, but run in continuous series almost to base of ocellarium; eyes in female separated by one-quarter total head-width, frons black, about three times width of one parafrontal; tomentum on face silver; antennae dark brown; palpi orange.

Thorax. Shining green; two pairs of postsutural acrostichal bristles.

Abdomen. Covered with short upstanding hairs, and therefore less shining than in *L. caesar*; second abdominal segment may have a row of semi-erect marginal setae, but they are never sufficiently pronounced to be regarded as marginal macrochaetae. Genitalia less robust than in *L. caesar*; median forceps diverge, curve forwards, and taper to points; lateral forceps longer than median forceps, also curving forwards (text-fig. 7).

Wings. Sometimes very slightly infuscated at the base; basicostal scale black; subcostal sclerite with a few inconspicuous wiry black hairs among thick dark brown decumbent pubescence. Lower squama sometimes slightly darkened.

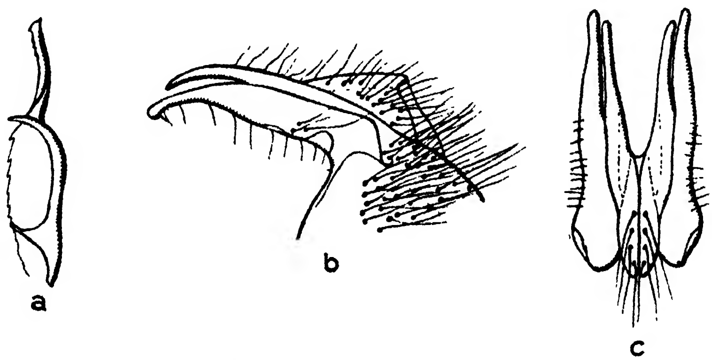
Legs. Black; one antero-dorsal bristle on middle tibia.

This species resembles *L. caesar* (L.) very closely, but differs from it in having the eyes in the male rather wider apart, a small hypopygium, and distinctive genitalia.

The females cannot easily be distinguished from those of *L. caesar* and *L. ampullacea*, but on the whole they are less shiny, the hairs on the subcostal sclerite are less conspicuous, and the frons narrows rather more anteriorly. *L. illustris* is well established in northern and central Europe, and appears to have spread to the eastern coast of Asia; also, it is one of the commonest species in N. America, where it has always been identified as *L. caesar* (L.),

a species which I do not think has been introduced into that continent. The misconception is partly due to the fact that the presence of bristles on the subcostal sclerite has been regarded as a character specific for *L. caesar*, whereas this character is common to a number of species in the genus. All records of *L. caesar* from Canada and the United States may be taken as referring to *L. illustris*, but records from Mexico and further south probably refer to other American species. Collin (1926) synonymized *L. parvula* (Mg.) with *L. illustris* (Mg.); the 'Palaearctic Catalogue' erroneously placed this name as a synonym of *L. silvarum* (Mg.).

TEXT-FIG. 7.



Genitalia of *Lucilia illustris*, × 44.
a, penis, lateral view; *b*, forceps, lateral view; *c*, forceps, dorsal view.

LUCILIA AMPULLACEA Vill.

Lucilia ampullacea Vill., Bull. Mus. Paris xxviii, p. 515 (1922).
Lucilia flavipennis Kram., *nec* Macq., Abh. Naturforsch. Ges. Görlitz, p. 283 (1917).
Lucilia krameri Ség., Encyc. Ent. ser. B, ii, p. 94 (1925).
Caesariceps flavipennis (Kram.), Rev. Zool. Russe iv, fasc. 1 (1925). (Entom. Mitt. xvii, p. 337 (1928).)

Distribution.—Germany, Australia, Italy, Algeria, France, England, Japan.

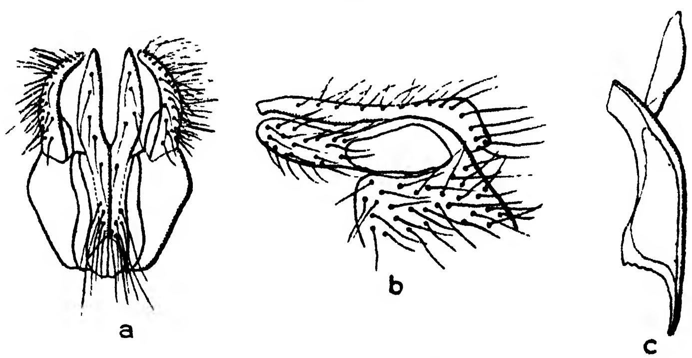
This species resembles *L. caesar* so closely externally that it was not recognized as distinct until Kramer examined the genitalia. It is generally a little smaller than the average *L. caesar* (L.), possibly a little less shining, the chaetotaxy is very much more strongly developed, the hypopygium is not prominent, and the sternites and ventral edges of the tergites have long thick bristles. The genitalia (text-fig. 8) are less heavily chitinized than in *L. caesar*; the median forceps are dark, rather broad, and diverge slightly, while the lateral forceps are testaceous, covered with long hair distally, and distended to form 'ampullae' proximally. The penis, as will be seen from text-fig. 8, is quite different from that of *L. caesar*.

The females are difficult to distinguish from those of *L. caesar* and *L. illustris*, but the frons is rather narrower than in *L. caesar*, and the stronger chaetotaxy and slight yellow tinge on the anterior border of the wing may aid in their identification.

Séguy (1925) suggested the name *krameri*, as *flavipennis* was preoccupied by *L. flavipennis* Macq., from the oriental region ; later (1928) he synonymized *L. krameri* with *L. ampullacea* Vill.

The species appears to be very generally established in Europe, and a single male from Japan in the Paris Museum leads one to expect that it will eventually be taken in Northern Asia.

TEXT-FIG. 8.



Genitalia of *Lucilia ampullacea*, × 60.
a, forceps, dorsal view ; *b*, forceps, lateral view ; *c*, penis, lateral view.

LUCILIA INFERNALIS (Vill.).

**Phumonesia infernalis* Vill., Bull. Soc. Ent. Fr., p. 307 (1914).

Distribution.—Africa : Tanganyika, Kenya Colony, Uganda, S. Rhodesia.

♂♀.—*Head.* Eyes in male almost holoptic, separated by very much narrowed and contiguous parafrontals, which are bare except for the frontal bristles ; eyes in female separated by distance equal to one-quarter width of head ; tomentum on face silver ; antennae dull brown, lighter at base of third segment ; palpi orange.

Thorax. Deep blue to purple, silver-dusted anteriorly and on the pleurae ; three postsutural acrostichal bristles.

Abdomen. Deep blue to purple, silver-dusted ventrally ; hypopygium inconspicuous, genitalia as in text-fig. 9.

Wings. Hyaline, the anterior border heavily infuscated (text-fig. 10) ; basicostal scale black ; subcostal sclerite with black upstanding hairs ; upper squama white, lower squama infuscated.

Legs. Brownish black, middle tibia with one antero-dorsal bristle.

The types of *L. infernalis* (Vill.) in the Vienna Museum are very crumpled and discoloured, and look as though they had at one time been in alcohol; this may possibly account for the antennae being dull brown instead of orange.

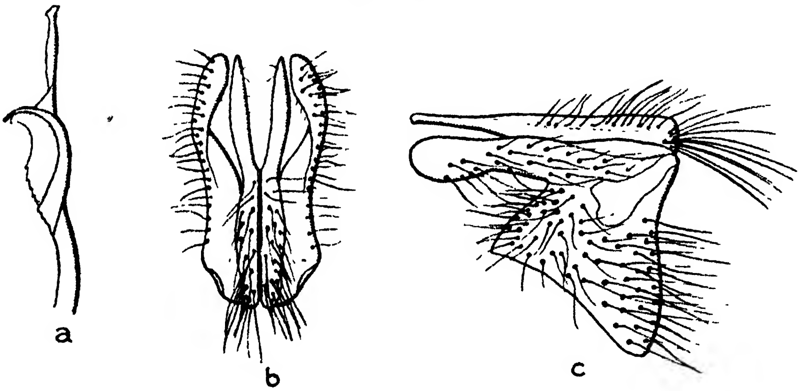
LUCILIA INFERNALIS (Vill.) var. CAERULEA (Ség.).

**Roubaudiella caerulia* Ség., Bull. Soc. Path. Exot. xviii, p. 735 (1925).
**Lucilia (Lucilia) nigricosta* Mall., Ann. & Mag. Nat. Hist. (9) xvii, p. 507 (1926).
Phumonesia villeneuvi Curr., Amer. Mus. Nov. no. 248, p. 4 (1927).

Distribution.—Africa: Uganda, Belgian Congo, Nigeria, Gold Coast.

This variety differs from *L. infernalis* (Vill.) in having two pairs of postsutural acrostichal bristles, dark brown antennae, and a uniformly lightly infuscated

TEXT-FIG. 9.



TEXT-FIG. 10.

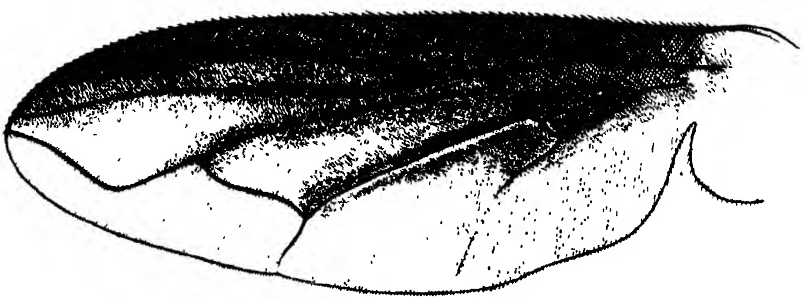


Fig. 9.—Genitalia of *Lucilia infernalis*, × 48. *a*, penis, lateral view; *b*, forceps, dorsal view; *c*, forceps, lateral view.
Fig 10.—Wing of *Lucilia infernalis*, × 15.

squama. It will be seen that the geographical distribution of the two forms overlaps, and I am inclined to think that, when more material is available for study, they may prove to be a single variable species. The genitalia of the two forms are indistinguishable.

In the type and paratype of *L. nigricosta* Mall. there are only two post-sutural acrostichal bristles, although it is stated in the original description that there are three.

LUCILIA PAPUENSIS Macq.

**Lucilia papuensis* Macq., Mem. Soc. Roy. Sci. Agric. Arts Lille, p. 298 (1842); Dipt. Exot. ii, p. 141 (1842).
**Musca metilia* Walk., List Dipt. Brit. Mus. iv, p. 898 (1849).
**Musca tifata* Walk., List Dipt. Brit. Mus. iv, p. 871 (1849).
**Lucilia cyaneo-marginata* Macq., *nec* Mall., Mem. Soc. Roy. Sci. Agric. Arts Lille, p. 221 (1851); Dipt. Exot. Suppl. iv, p. 248 (1851).
**Musca inducta* Walk., Dipt. Saunders., p. 335 (1852).
Lucilia azurea Dol., *nec* R.-D., Nat. Tijdschr. Ned. Ind. xvii, p. 111 (1858).
**Musca marginifera* Walk., Journ. Proc. Linn. Soc. iii, p. 105 (1859).
**Musca inscribens* Walk., Journ. Proc. Linn. Soc. iv, p. 136 (1860).
**Musca nitescens* Walk., Journ. Proc. Linn. Soc. v, p. 302 (1861). [*L. rutescens* of Patton, 1925 ?]
**Lucilia nosocomiorum* Dol., Nat. Tijdschr. Ned. Ind. xiv, p. 413 (1857).
**Somomyia nebulosa* Big., *part.*, Bull. Soc. Zool. Fr., p. 604 (1887).
**Lucilia albopilosa* S.-W., *part.*, Rec. Ind. Mus. xxviii, p. 131 (1926).
**Lucilia calviceps* Bezzi, Bull. Ent. Res. xvii, p. 238 (1927).

Distribution.—India, Ceylon, Malay Peninsula, Siam, Java, Borneo, New Guinea, Lombok, S. China, Aru, Celebes, Amboina, Ternate, Philippine Is. Australia: Queensland and New South Wales. N. Hebrides. Endermo (Japan ?).

♂♀.—*Head.* Frons in male obliterated for a short space, parafrontals much narrowed, eyes separated, at point of closest approximation, by distance equal to width of third antennal segment; in female eyes separated by one-quarter total width of head, frons black, about twice the width of one parafrontal; third antennal segment very short and slender, three and a half to four times length of second segment, slightly rufous at the base; tomentum of face greyish silver.

Thorax. Shining green to purple, lightly dusted anteriorly; two pairs postsutural acrostichal bristles inserted at the level of the two posterior pairs of dorso-central bristles.

Abdomen. Shining green to purple, the posterior margins of the second and third visible segment sometimes darkened. Hypopygium inconspicuous: genitalia as in text-fig. 11; median forceps pointed, slightly divergent, lateral forceps not very strongly chitinized and inconspicuously haired; penis characteristic for the species.

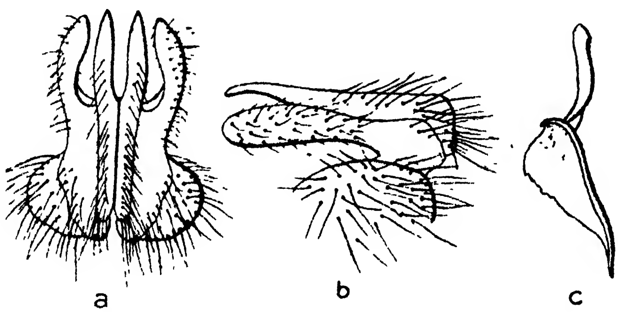
Wings. Basicostal scale black; subcostal sclerite with a few wiry hairs (sometimes very difficult to see); base of wing very faintly darkened and remainder greyish; squama dirty white to dark brown.

Legs. Black; one antero-dorsal bristle to middle tibia in male (a second small one may occasionally be present above it); the female always has two well-developed bristles on the middle tibia.

This species has repeatedly been confused with *L. porphyrina* (Walk.) and *Hemipyrellia ligurriens* (Wied.); the synonymy is consequently very involved, and a discussion of its ramifications would be useless. Bigot's cotypes of *Somomyia nebulosa* consist of two males and a female; one male is a specimen of *L. porphyrina* (Walk.), but the remaining specimens are typical *L. papuensis* Macq. The name *cyaneo-marginata* Macq. has recently been adopted by Malloch (1927) for *Hemipyrellia ligurriens* (Wied.), but an examination of the type shows that, as Patton (1925) stated, it is the same species as *L. nosocomiorum* Dol., and therefore a synonym of *L. papuensis* Macq.

In the types of Bezzi's *L. calviceps* from the N. Hebrides, the wings are rather more deeply infuscated than is usual, but in all other respects they are typical *L. papuensis* Macq.; there is also a series of specimens in the Berlin Museum from Bismarck Archipelago, showing the same wing-character.

TEXT-FIG. 11.



Genitalia of *Lucilia papuensis*, × 40.
a, forceps, dorsal view; *b*, forceps, lateral view; *c*, penis, lateral view.

LUCILIA SINENSIS, sp. n.

A very large species with holoptic eyes.

Distribution.—China. Szechuan.

♂.—*Head.* Eyes quite contiguous for a short space; antennae short, third segment four times length of second and very slightly rufous at the base; jowls short and rounded; tomentum on parafacials grey over reddish ground-colour (text-fig. 12).

Thorax. Green to purple; two pairs of postsutural acrostichal bristles arranged as in *L. papuensis* Macq.

Abdomen. Green to purple; macrochaetae not strongly developed; genitalia as in text-fig. 13, median and lateral forceps much as in *L. papuensis* Macq., penis very similar to that of *L. porphyrina* (Walk.).

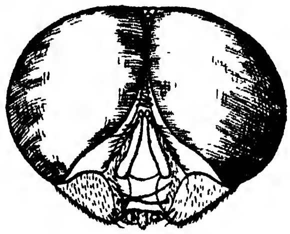
Wings. Slightly infuscated at the base; squama dark brown; bristles on subcostal sclerite inconspicuous.

Legs. Black ; middle tibia of male with one antero-dorsal bristle.

Two males, Chin-Fu-San, W. China (*W. A. Maw*).

This species differs from *L. papuensis* Macq. in the abnormally large size, holoptic eyes, and shape of the penis.

TEXT-FIG. 12.



TEXT-FIG. 13.

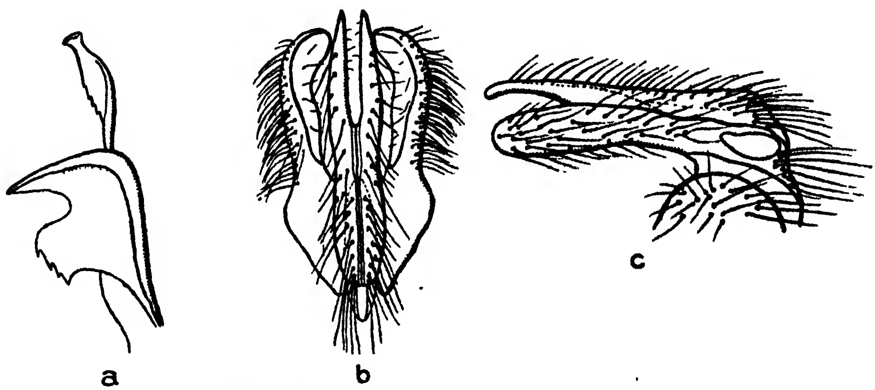


Fig. 12.—Head of *Lucilia sinensis*, × 8.

Fig. 13.—Genitalia of *Lucilia sinensis*, × 46. *a*, penis, lateral view ; *b*, forceps, dorsal view ; *c*, forceps, lateral view.

LUCILIA PORPHYRINA (Walk.).

**Musca porphyrina* Walk., Journ. Proc. Linn. Soc. i, p. 24 (1857).

**Somomyia obesa* Big., Ann. Soc. Ent. Fr. (5) vii, p. 43 (1877).

**Somomyia pachysoma* Big., Bull. Soc. Zool. Fr., p. 603 (1887). [=*L. pachymosa* of Patton, 1925 ?]

**Somomyia nebulosa* Big., *part.*, Bull. Soc. Zool. Fr., p. 604 (1887).

? *Lucilia craggii* Patton, Ind. Journ. Med. Res. ix, p. 553 (1922).

**Somomyia japonica* Big., Ann. Soc. Ent. Fr. (5) vii, p. 254 (1877).

Distribution.—India, Ceylon, Sumatra, Java, Malay Peninsula, Philippine Is., China, Japan.

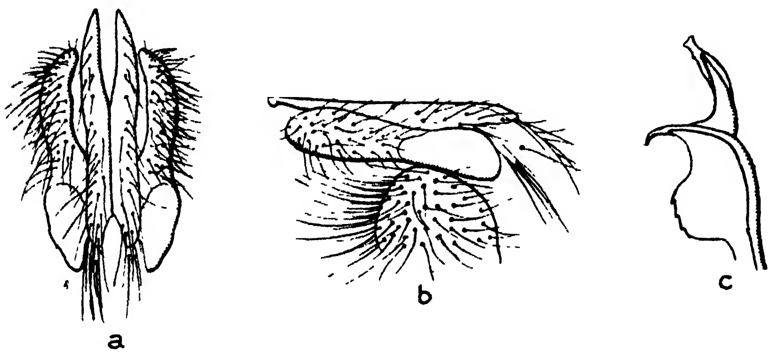
♂♀.—*Head.* Eyes in male more closely approximated than in *L. papuensis* Macq., the parafrontals being reduced to a fine line ; in female eyes separated by rather more than one-fifth total head-width ; third segment of antenna

five times as long as second, narrower in male than in female, dark brown. Parafacials brown with a silvery sheen.

Thorax. Green to purple, very slightly dusted anteriorly; two pairs of postsutural acrostichal bristles, which lie rather in front of the two corresponding pairs of postsutural dorso-central bristles.

Abdomen. Shining green to purple; hypopygium inconspicuous; male genitalia as in text-fig. 14, median forceps pointed, flattened, and hardly divergent; lateral forceps dark brown at tips. lighter in colour basally, heavily haired; lateral lobe small, but thickly covered with long hairs; penis characteristic.

TEXT-FIG. 14.



Genitalia of *Lucilia porphyrina*, × 40.
a, forceps, dorsal view; *b*, forceps, lateral view; *c*, penis, lateral view.

Wings. Faintly and uniformly tinged with brown, which deepens slightly at the base, basicostal scale black; subcostal sclerite with stiff black hairs; squama usually testaceous to very dark brown, occasionally white.

Legs. Dark brown; middle tibia with one antero-dorsal bristle in both sexes.

Bigot in his description of *Somomyia obesa* does not state the number of specimens examined, but four were found over his label. Of these, two belong to *Hemipyrellia ligurriens* (Wied.) and two to *L. porphyrina* (Walk.). Bigot refers to the squamæ as 'pale testaceous', a description applicable to the latter species, but not to the former, where the squamae are a dazzling white. For this reason I regard two of the specimens only as cotypes, and consider *S. obesa* Big. to be a synonym of *L. porphyrina* (Walk.).

In the Palaearctic Catalogue *S. japonica* Big. is placed as a synonym of *L. caesar* (L.), but one at least of the two female cotypes is *L. porphyrina* (Walk.), while the other, which has a white squama, is in such poor condition that it is unidentifiable. I have seen two other female specimens from Japan, both with white squamae, which are also typical *L. porphyrina* (Walk.).

Séguy (1925 *a*) erected the genus *Argoracrites* for a freak female of this species, in which the anterior pair of postsutural acrostichal bristles, as well as the

remaining two pairs were weakly developed; the description of the genotype has, however, never been published, so that *Argoracrites* remains a *nomen nudum*.

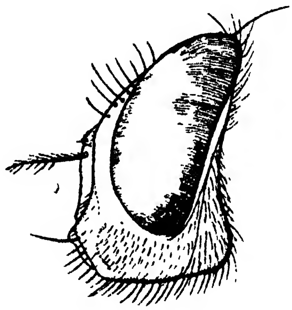
LUCILIA PORPHYRINA var. FLAVICORNIS Mall.

Lucilia flavicornis Mall., Proc. Linn. Soc. N.S.W. lii, p. 322 (1927).

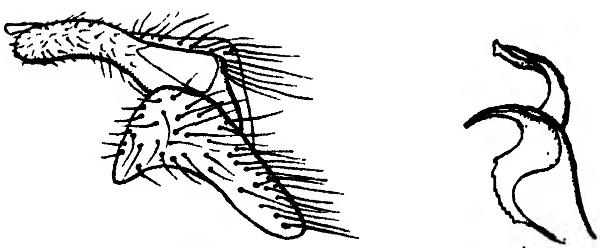
Through the kindness of Mr. G. H. Hardy I have seen a number of specimens from Australia which agree perfectly with Malloch's description of *L. flavicornis*. Except for the brilliant orange antennae, they seem to be typical *L. porphyrina* (Walk.); I prefer to consider them as a geographical race, and not as a separate species.

Distribution.—Australia: Queensland, Brisbane.

TEXT-FIG. 15.



TEXT-FIG. 16.



a b

Fig. 15.—Head of *Lucilia graphita*, × 10.
Fig. 16.—Genitalia of *Lucilia graphita*, × 50. *a*, forceps, lateral view; *b*, penis, lateral view.

LUCILIA GRAPHITA Snn.

Lucilia graphita Snn., Bull. Bern. Bish. Mus. xxxi, p. 72 (1926).

Distribution.—Hawaii: Laysan Is., Ocean Is., Midway Is., Pearl and Hermes Reef.

♂♀.—*Head.* Eyes separated in male by a very fine line, in female by slightly more than one-quarter total width of head; frons in male partially obliterated,

reddish above insertion of antennae, in female about twice width of one parafrontal, narrowing anteriorly, dark reddish black ; parafrontals in female silvery anteriorly, black towards vertex, in male reduced to a fine line between the eyes; face and parafacials covered with yellowish-grey tomentum ; medianae and epistome reddish orange ; jowls dark grey ; antennae reddish basally, dark brown distally ; palpi orange (text-fig. 15).

Thorax. Shining blue-black, with a slight tinge of green (hardly metallic) ; chaetotaxy strongly developed , three post-sutural acrostichal bristles.

Abdomen. Similar in colour to thorax ; no marginal macrochaetae on second visible segment ; hypopygium inconspicuous ; male genitalia as in text-fig. 16.

Wings. Hyaline, slightly infuscated basally ; basicostal scale dark brown ; subcostal sclerite with stiff black bristles ; squama rather transparent, lightly infuscated.

Legs. Dark brownish black ; middle tibia with one antero-dorsal bristle.

In the original description it is stated that this species has only two pairs of postsutural acrostichal bristles, but Dr. Aldrich has very kindly examined the types for me and finds that there are three pairs, as is the case in all the specimens which I have seen. The species is striking and easily recognizable on account of the peculiar colouring of the head and body.

LUCILIA SERIÇATA (Meig.).

Musca sericata Mg., S.B. v, p. 53 (1826).
**Musca nobilis* Mg., S.B. v, p. 56 (1826).
**Chrysomyia capensis* R.-D., Myodaires, p 451 (1830).
**Lucilia basalis* Macq., Mém. Soc. Roy. Agric. Arts Lille, p 305 (1842); Dipt. Exot. ii, p. 148 (1842).
**Lucilia flavipennis* Macq., *nec* Kram., Mém. Soc. Roy. Agric. Arts Lille, p. 296 (1842); Dipt. Exot. iii, p. 139 (1842).
**Musca lagyra* Walk., List. Dipt. Brit. Mus. iv, p. 885 (1849).
* ? *Lucilia sayi* Jaen., Abh. Senck. Ges. vi, p. 375 (1867).
Lucilia frontalis (Lw. & Br. & von B.), *nom. nud.*
Lucilia barberi Tns., Smiths. Misc. Coll. li, p. 121 (1908).
Lucilia giraulti Tns., Smiths. Misc. Coll. li, p. 121 (1908).

Distribution.—World-wide.

♂♀.—*Head*. Eyes in male separated at point of closest approximation by distance equal to two and a half to three times width of third antennal segment ; parafrontals in male covered with fine hairs as well as frontal bristles, narrow towards vertex, leaving frons slightly broader above antennae than at this point ; distance between eyes in female rather more than one-third total width of head, parafrontals covered with minute bristles, frons about twice width of one parafrontal ; antennae dark brown ; palpi orange.

Thorax. Shining green ; three postsutural acrostichal bristles.

Abdomen. Shining green, evenly covered on dorsum and venter with short bristles ; no macrochaetae on margin of second visible segment ; hypopygium inconspicuous, genitalia as in text-fig. 17 ; in female, abdomen heavily dusted

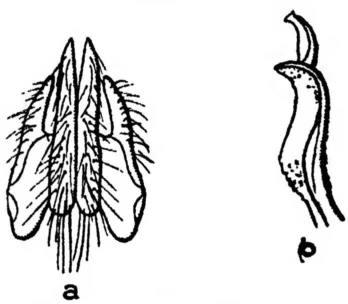
with silver tomentum, and with a dark longitudinal line, apparent in certain lights, on second visible segment.

Wings. Hyaline; basicostal scale yellow; subcostal sclerite with decumbent, dark brown felted pubescence; squama white.

Legs. Black; middle tibia with one antero-dorsal bristle.

This widely distributed species is commonest in the Palaearctic and Ethiopian Regions, and has probably been more recently introduced into the Oriental, Australian, Nearctic, and Neotropical Regions, occurring apparently with least frequency in S. America. In temperate climates the fly is comparatively harmless, but in Africa and Australia it is one of the species most intimately connected with the blowing of wool, and is a very serious pest. Accounts of the damage done and methods of prevention used in Australia will be found in a series of papers by W. W. and J. Froggatt the most recent of them being cited in the list of literature at the end of this paper; an account of

TEXT-FIG. 17.



Genitalia of *Lucilia sericata*, × 40.
a, forceps, dorsal view; *b*, penis, lateral view.

preventive measures employed in Africa has been published recently by Smit (1929). This fly is also known to cause myiasis in man.

L. sericata shows rather striking regional colour-changes, being bright green in Europe and Africa, dull, rather bronzy green in India, and a peculiar coppery colour in New Zealand.

The synonymy of *L. basalis* Macq. was established by Séguy (1925); the published locality for this species is America, but the type-specimen indicates that it comes from Mogador. *Lucilia flavipennis* Macq. is undoubtedly *L. sericata*, but I have seen no other specimen of this species from Ceylon. *L. barberi* and *L. giraulti* were synonymized by Tothill (1913), and this has been confirmed by Dr. Aldrich.

LUCILIA CUPRINA (Wied.).

Musca cuprina Wied., Auss. Zweifl. Ins. ii, p. 654 (1830).
**Lucilia amica* R.-D., Myodaires, p. 543 (1830).
**Lucilia dorsalis* R.-D., Myodaires, p. 453 (1830).

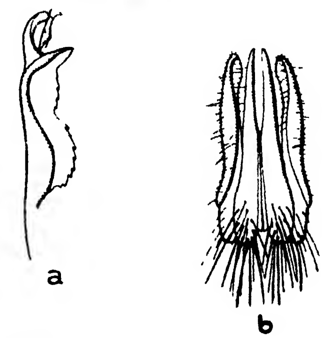
***Lucilia elegans* R.-D., *nec* Macq., Myodaires, p. 458 (1830).
***Lucilia argyricephala* Macq., Mém. Soc. Roy. Agr. Arts Lille, p. 326 (1846); Dipt. Exot. Suppl. i, p. 198 (1846).
***Musca fucina* Walk., List. Dipt. Brit. Mus. iv, p. 883 (1849).
Lucilia leucodes Frauenf., Verh. Zool.-bot. Ges. Wien xvii, p. 453.
***Musca serenissima* Walk., Ins. Saund. pt. iv, p. 340 (1852).
***Musca temperata* Walk., Ins. Saund. pt. iv, p. 340 (1852).
Somomyia pallifrons Big., Ann. Soc. Ent. Fr. (5) vii, p. 258 (1877).
Lucilia pallescens Snn., Insec. Inscit. Mens. xii. p. 76 (1924).

Distribution.—Africa, Madagascar, Mauritius, S. Asia, E. Indies, Japan, Australia, N. & S. America.

♂♀.—*Head.* Eyes, at point of closest approximation, separated by distance equal to three or four times width of third antennal segment; frons at narrowest point about twice width of one parafrontal at same point; parafrontals some-

TEXT-FIG. 18.

TEXT-FIG. 19.



Lucilia cuprina.

Fig. 18.—Lateral view of abdomen of ♂, × 10.
Fig. 19.—Genitalia, × 35. *a*, penis, lateral view; *b*, forceps, dorsal view.

times with fine hairs outside the frontal bristles in male; distance between eyes in female one-third width of head, parafrontals bare except for frontal bristles, frons twice width of one parafrontal.

Thorax. Shining green; three postsutural acrostichal bristles.

Abdomen. Characteristic shape in male (text-fig. 18), shining green in both sexes, the sternites and edges of tergites with bunches of long thick hairs: hypopygium rather prominent in male, genitalia similar to those of *L. sericata*, but the forceps slimmer and the penis rather different in shape (text-fig. 19).

Wings. Hyaline, slightly yellow at the base; basicostal scale yellow; subcostal sclerite covered with short decumbent yellowish-brown pubescence; squama white.

Legs. Black; middle tibia with one antero-dorsal bristle.

This species is typically African, but has spread through southern Asia, and has been introduced comparatively recently into Australia and N. and S.

America. In Africa and Australia it appears to be as harmful to the sheep-farmer as *L. sericata*, and, like this species, it becomes noticeably dull and copper-coloured in the Oriental Region, although usually a brilliant green in Africa.

I have seen a specimen of *L. cuprina* in the Vienna Museum identified as *L. leucodes* Frauenf. by Brauer and von Bergenstamm, but I have not seen the type of this species.

LUCILIA REGALIS (Meig.).

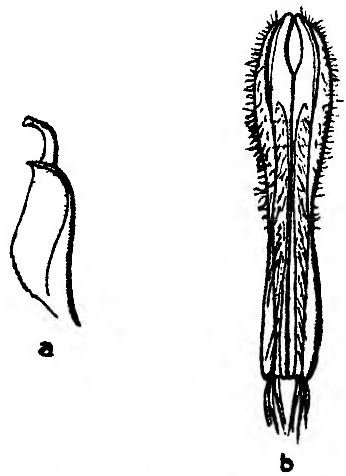
**Musca regalis* Mg., S.B. v, p. 54 (1826).

**Calliphora longilobata* Pand., Rev. Entom. xv, p. 219 (1896).

Distribution.—Europe: Germany, Austria. Asia: China, Szechuan.

♂.—*Head.* Distance between the eyes in male, at point of closest approximation, three to three and a half times width of third antennal segment; frons

TEXT-FIG. 20.



Genitalia of *Lucilia regalis*, × 54.
a, penis, lateral view; *b*, forceps, dorsal view.

at its narrowest twice as wide as one parafrontal; parafrontals with a few fine hairs outside frontal bristles; antennae dark brown; palpi tawny to dark brown.

Thorax. Shining green; three postsutural acrostichal bristles.

Abdomen. Second visible segment with a pair of marginal macrochaetae; hypopygium rather prominent, lobes of last sternite long and strongly bristled; male genitalia very characteristic (text-fig. 20), forceps slim and elongate, the median pair fused almost to the tip.

Wings. Hyaline, slightly grey; basicostal scale yellow, subcostal sclerite with soft yellowish decumbent hairs; squama white.

Legs. Black; middle tibia with two antero-dorsal bristles.

Collin (1926) identifies this species with the *longilobata* of Stein's paper (1924), but considers that this latter species cannot be the same as that of Pandellé, which is described as having no upstanding macrochaetae on the second visible abdominal segment; Séguy (1928), after examining Pandellé's type, is of the opinion that the macrochaetae are present, but not very obvious, as the specimen is crumpled and poorly chitinized.

I have not seen any female specimen which could be referred with certainty to this species.

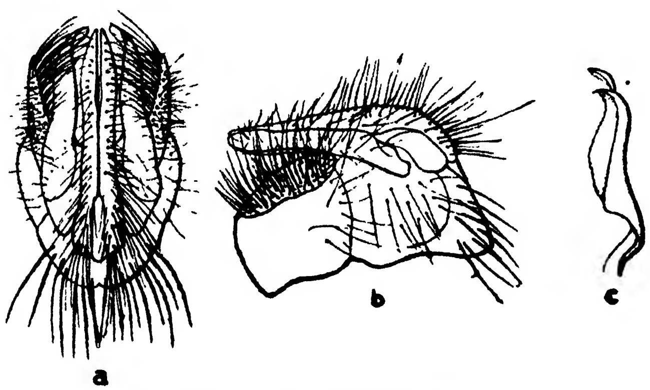
LUCILIA PILOSIVENTRIS Kram.

Lucilia pilosiventris Kram., *nec* Richards, Ent. Rundsch. xxvii, p. 35 (1910).

Distribution.– Europe: France, Germany, Austria. Asia: China, Szechuan.

♂.—*Head.* Eyes in male widely separated, distance between them at point of closest approximation equal to length of third antennal segment; frons

TEXT-FIG. 21.



Genitalia of *Lucilia pilosiventris*, × 55.
a, forceps, dorsal view; *b*, forceps, lateral view; *c*, penis, lateral view.

twice width of one parafrontal at narrowest point; parafrontal with numerous fine hairs outside frontal bristles; parafacials with peculiarly glistening silver tomentum; antennae dark brown; palpi tawny to dark brown.

Thorax. Shining green; three postsutural acrostichal bristles.

Abdomen. Shining green; second visible segment without marginal macrochaetae; venter with thick tufts of strong bristles, lobes of last sternite broad and heavily bristled; hypopygium projecting slightly, genitalia (text-fig. 21) with very well-developed lateral lobes, covered with stiff hairs; median and lateral forceps rather hairy.

Wings. Hyaline; basicostal scale yellow; subcostal sclerite with soft tawny pubescence; squama white.

Legs. Black; middle tibia with two or three antero-dorsal bristles.

This species does not appear to be common, but its occurrence in China as well as in Europe leads one to think that it may be fairly widely distributed. I have seen three males in the Vienna Museum, one in the Berlin Museum, and a long series in the Paris Museum, but no specimen which could with certainty be regarded as a female of this species; they are not easily distinguished from those of *L. richardsi* Coll., but the distance between the eyes is probably very wide.

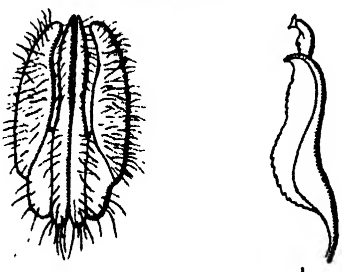
LUCILIA RICHARDSI Collin.

Lucilia richardsi Collin, Trans. Ent. Soc. Lond., p. 259 (1926).
Lucilia splendida Verr., *nec* Mg., List. Brit. Dipt., p. 27 (1901).
Lucilia pilosiventris Richards, *nec* Kram., Trans. Ent. Soc. Lond., p. 255 (1926).

Distribution.—Europe: England, France, Holland, Austria, Dalmatia, Illyria, Caucasus. ? N. America.

♂♀.—*Head.* Eyes in male at point of closest approximation, separated by twice width of third antennal segment; frons at its narrowest twice width of one parafrontal; frons and parafrontals in female occupy rather more than

TEXT-FIG. 22.



Genitalia of *Lucilia richardsi*, × 55.
a, forceps, dorsal view; *b*, penis, lateral view.

one-third total width of head; parafrontals with a few fine hairs outside the frontal bristles in both sexes; antennae dark brown; palpi yellow to brown.

Thorax. Shining blue-green, sometimes with bright coppery reflections, three postsutural acrostichal bristles.

Abdomen. Shining green, rather closely covered with short bristles; no definite macrochaetae on margin of second visible segment, but the row of bristles in this position tend to be somewhat emphasized; hypopygium inconspicuous, but lobes of last sternite haired and rather prominent; genitalia characteristic (text-fig. 22), median forceps fused nearly to tip, where they separate with a slight bulbous swelling; lateral forceps dark brown, hairy; penis elongate.

Wings. Hyaline; basicostal scale yellow; subcostal sclerite with yellowish felted hairs; squama white.

Legs. Black; middle tibia with two antero-dorsal bristles in both sexes.

Richards (1926), in his paper on British Lucilias, suggested tentatively that this species might be *L. pilosiventris* Kram., but Collin (1926) pointed out that in this latter species the distance between the eyes in the male is very much greater, and the sternites more definitely hairy ; he therefore proposed the name *richardsi* for the British species with two antero-dorsal bristles to the middle tibia.

In the Paris Museum two specimens from Carolina are placed above the label "*ignita*" ; they are not the types of Robineau-Desvoidy's species described under *Pyrellia*, but one of the specimens appears to be *L. richardsi* ; further data, however, are necessary before the species is considered to be established in America.

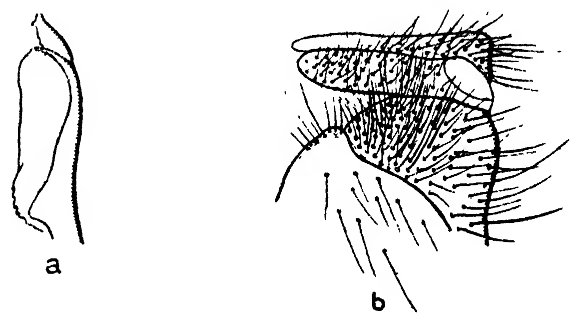
LUCILIA THATUNA Snn.

Lucilia thatuna Snn., Proc. Ent. Soc. Wash. xxviii, p. 132 (1926).

Distribution.—N. America : Idaho.

♂♀.—*Head.* Eyes in male separated, at point of closest approximation, by a distance slightly less than width of third antennal segment, in female by

TEXT-FIG. 23.



Genitalia of *Lucilia thatuna*, × 54.
a, penis, lateral view ; *b*, forceps, lateral view.

one-quarter total head-width ; parafrontals in male narrowed and contiguous for a short space, with fine hairs outside the frontal bristles, in female equal in width to one-quarter width of frons ; tomentum on parafacials silver ; antennae dark brown, second segment slightly redidsh ; palpi dark orange.

Thorax. Shining blue-green, slightly dusted anteriorly ; three po. tsutural acrostichal bristles.

Abdomen. Shining blue-green ; second visible segment with a pair of marginal macrochaetae ; venter rather strongly haired ; hypopygium inconspicuous ; genitalia as in text-fig. 23, hairy.

Wings. Hyaline ; basicostal scale yellow ; subcostal sclerite with soft brown pubescence ; squama white to light brown.

Legs. Black ; middle tibia with one antero-dorsal bristle.

In his description Shannon notes that the propleura is black setose, and the back of the head partly so.

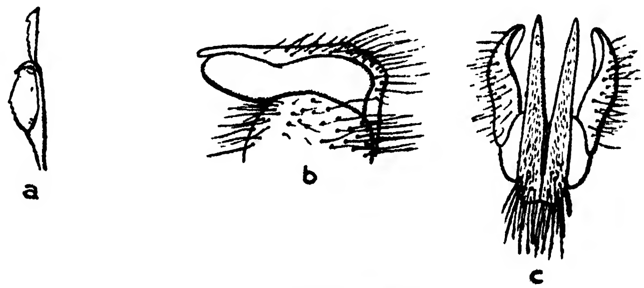
LUCILIA CLUVIA (Walk.).

**Musca cluvia* Walk., List Dipt. Brit. Mus. iv, p. 885 (1849).
Lucilia pilatei Hough, Zool. Bull. ii, p. 287 (1899).
? *Lucilia problematica* Johns., Ann. Ent. Soc. Amer. vi, p. 448 (1913).

Distribution.—N. America: south-eastern United States. West Indies: Cuba.

♂♀.—*Head.* Eyes separated in male, at point of closest approximation, by a distance equal to two and a half times width of the third antennal segment, in female by rather less than one-quarter total width of head; frons in female about twice width of one parafrontal at narrowest point, parafrontals in female with fine setulae outside frontal bristles; antennae dark brown, second segment and base of third slightly rufous; tomentum silver, becoming rather

TEXT-FIG. 24.



Genitalia of *Lucilia cluvia*, × 40.
a, penis, lateral view; *b*, forceps, lateral view; *c*, forceps, dorsal view.

golden about the mouth-region; palpi orange; hairs below and behind jowls mainly golden, a few black hairs intermixed.

Thorax. Shining green, grey-dusted anteriorly; two postsutural acrostichal bristles.

Abdomen. Shining green; hind margins of second and third segments sometimes darkened; male genitalia as in text-fig. 24, inconspicuous.

Wings. Hyaline; basicostal scale yellow; subcostal sclerite with soft golden pubescence; squama white to light brown.

Legs. Brown; middle tibia with one antero-dorsal bristle.

LUCILIA SILVARUM (Meig.).

Musca silvarum Mg., S.B. v, p. 53 (1826).
? *Lucilia brunnicosa* R.-D., Myod., p. 459 (1830).
**Onesia lucilioides* v. d. W., Biol. Centr.-Amer., Dipt. ii, p. 288 (1896).
Lucilia nigripalpis Towns., Smiths. Misc. Coll. li, p. 120 (1908).
Bufolucilia silvarum (Mg.) Towns., Proc. U.S. Nat. Mus. lvi, p. 542 (1919).

Distribution.—Europe, Japan, N. America,

♂♀.—*Head.* Frons in male at narrowest point slightly broader than one parafrontal, in female rather more than twice this width; eyes separated in male, at point of nearest approximation, by twice width of third antennal segment, in female separated by one-third total width of head; antennae and palpi dark brown.

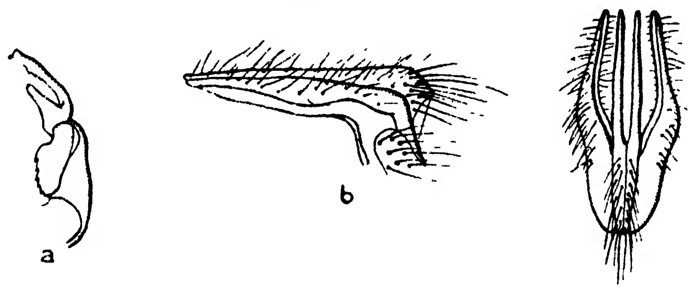
Thorax. Shining green; three postsutural acrostichal bristles.

Abdomen. Shining green; a pair of well-developed macrochaetae on margin of second visible segment and numerous macrochaetae on margins of third and on fourth visible segments; hypopygium slightly projecting from abdomen; genitalia (text-fig. 25) characteristic of the species.

Wings. Hyaline; basicostal scale black; subcostal sclerite with soft, felted, decumbent, dark brown pubescence; squama white.

Legs. Black; middle tibia with one antero-dorsal bristle.

TEXT-FIG. 25.



Genitalia of *Lucilia silvarum*, × 40.
a, penis, lateral view; *b*, forceps, lateral view; *c*, forceps, dorsal view.

The species is common in Europe and N. America, and has frequently been confused with *L. bufonivora* Mon. The identity of *L. brunnicosa* R.-D. was suggested by Hough, but the original description does not agree very well with the present species. *L. nigripalpis* Tns. was synonymized by Tothill, and this has been confirmed in a letter from Dr. Aldrich.

I have seen one specimen of *L. silvarum* in the Paris Museum labelled *regalis* Mg., determined by Macquart; the locality given is S. Africa, but it is not very likely that *L. silvarum* has established itself there.

LUCILIA BUFONIVORA Mon.

Lucilia bufonivora Mon., Bull. Dep. Nord, Lille, viii, p. 25 (1876).
Bufolucilia bufonivora (Mon.) Tns., Proc. U.S. Nat. Mus. lvi, p. 542 (1919).
Lucilia elongata Snn., Insec. Inscit. Mens. xii, p. 76 (1924).

Distribution.—Europe; N. America: Oregon, Washington; China.

♂♀.—*Head.* Frons in male only slightly narrowed, about twice the width of one parafrontal at narrowest point; distance between eyes, at point of

nearest approximation, equal to twice width of third antennal segment; frons projects somewhat from general level of head; antennae dark brown; palpi dirty yellow to dark brown; distance between eyes in female equal to one-quarter total head-width, frons twice width of one parafrontal.

Thorax. Shining green; bristles long and strong, two postsutural acrostichals.

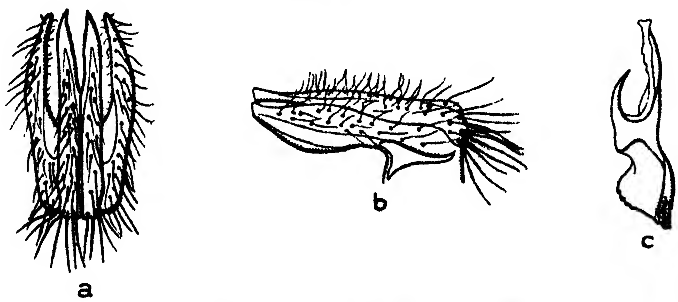
Abdomen. Shining green; strongly bristled, second visible segment with a row of well-developed marginal macrochaetae, venter and dorsum of third and fourth visible segments well bristled; hypopygium not prominent; genitalia (text-fig. 26) differ from those of *L. silvarum* in that the lateral forceps are almost straight and rounded apically.

Wings. Greyish, the colour rather intensified towards base; basicostal scale black; subcostal sclerite with dark brown, felted, decumbent pubescence; squama white, sometimes slightly infuscated.

Legs. Black; middle tibia with one antero-dorsal bristle.

Lucilia bufonivora has for long been known as a parasite of toads, but until recently it was considered to be identical with *L. silvarum*, and the parasitic

TEXT-FIG. 26.



Genitalia of *Lucilia bufonivora*. × 52.

a, forceps, dorsal view; *b*, forceps, lateral view; *c*, penis, lateral view.

habit in the larval stage was thought to be sporadic. Lestage (1925) separated *L. bufonivora* on anatomical characters, noting that this species has only two postsutural acrostichal bristles, while *L. silvarum* had three, and that there was a definite difference between the genitalia in the shape of the lateral forceps. The former character is not entirely reliable, as the chaetotaxy is rather variable in each species, but there is a further distinction in the shape of the head of the male, the sides of the frons being more nearly parallel, and the frons itself more protuberant in *L. bufonivora* than in *L. silvarum*. In the females the distance between the eyes is definitely less in the former than in the latter species.

Villeneuve (1914) is of the opinion that *L. bufonivora* is in the process of becoming established as a distinct species, and Mercier (1928) would refer to it as an '*espèce jointive*'.

I have examined a male specimen from Washington determined by Dr. Aldrich as *L. elongata* Snn., and am satisfied that it is identical with European specimens of *L. bufonivora*, although Séguy (1925) suggests that *L. elongata* is a good species.

There are numerous references to the parasitic habit of the larva in Europe; Stadler (1930) gives a good account of the attack on toads and development of the larvae, and gives references to earlier papers. (His specimens were determined as *L. silvarum* (Mg.), but this is almost certainly a mistake.)

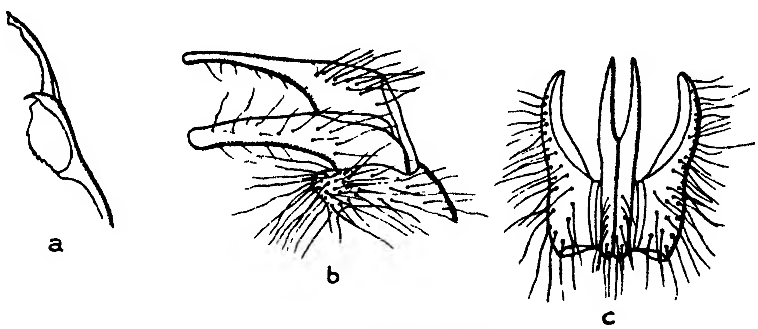
LUCILIA CAERULEIVIRIDIS Macq.

**Lucilia caeruleiviridis* Macq., Mém. Soc. Sci. Agric. Arts Lille, p. 133 (1855); Dipt. Exot. Suppl. v, p. 113 (1855).
Lucilia australis Tns., Smiths. Misc. Coll. li, p. 122 (1908).
Lucilia oculata Tns., Smiths. Misc. Coll. li, p. 123 (1908).

Distribution.—N. America: United States.

♂♀.—*Head.* Eyes in male very nearly contiguous, separated at point of closest approach by much compressed parafrontals, in female separated by rather less than one-quarter total head-width; frons in male entirely obliterated

TEXT-FIG. 27



Genitalia of *Lucilia caeruleiviridis*, × 52.
a, penis, lateral view; *b*, forceps, lateral view; *c*, forceps, dorsal view.

for a short space, in female about twice width of one parafrontal; parafrontals and parafacials covered with silver tomentum, the former bare except for the frontal bristles; antennae reddish brown, darker at the base; palpi orange.

Thorax. Shining green; two postsutural acrostichal bristles.

Abdomen. Shining green; genitalia inconspicuous (text-fig. 27).

Wings. Hyaline; basicostal scale pale yellow to dark brown; subcostal sclerite with soft golden pubescence.

Legs. Dark brown; middle tibia with one antero-dorsal bristle.

This species may readily be recognised in the male sex by the closely approximated eyes and the golden pubescence on the subcostal sclerite. Macquart's type is a female, but there is no doubt about its identity with *L. australis* Tns., as determined by Aldrich.

The female of *L. cluvia* Walk. is very similar to this species, but may be distinguished from it by the grey dusting between the humeri, numerous golden hairs below and behind the jowls, and series of minute setulae on the parafrontals outside the frontal bristles; in the female of *L. caeruleiviridis* the dorsum of the thorax is shining green anteriorly, the beard black, although intermixed with a few pale hairs, and the setulae on the parafrontals are very difficult to see, and may often be entirely absent.

Hough (1899) suggested that this species was a synonym of *L. sericata* Mg.

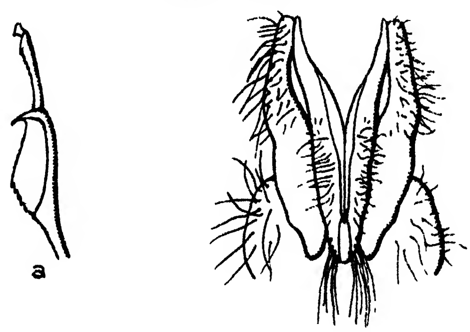
LUCILIA MEXICANA Macq.

**Lucilia mexicana* Macq., Mém. Soc. Sci. Agric. Arts Lille, p. 300 (1843); Dipt. Exot. ii, pt. 3, p. 143 (1843).
Lucilia unicolor Tns., Smiths. Misc. Coll. li, p. 121 (1908).
Lucilia infuscata Tns., Smiths. Misc. Coll. li, p. 123 (1908).

Distribution. N. America: Mexico, British Columbia. S. America: Guatemala, Paraguay, French Guiana.

♂♀. *Head.* Eyes in male, at point of closest approximation, separated by a distance equal to the width of third segment of antenna; frons almost

TEXT-FIG. 28.



Genitalia of *Lucilia mexicana*, × 66.
a, penis, lateral view; *b*, forceps, dorsal view.

obliterated at one point; in female eyes separated by one-quarter total head-width, frons twice width of one parafrontal; parafrontals with fine hairs outside the frontal bristles; tomentum of face grey; antennae dark brown, slightly rufous at the base; palpi yellow.

Thorax. Shining green, two postsutural acrostichal bristles.

Abdomen. Shining green; hypopygium inconspicuous; genitalia (text-fig. 28) with median forceps wide-spread at the tips, rather as in *L. illustris*, but more heavily chitinized, lateral forceps more flexible than in *L. illustris*.

Wings. Hyaline, slightly infuscated basally; basicostal scale dark brown to black; subcostal sclerite with dark brown decumbent pubescence; squama slightly infuscated.

Legs. Black; middle tibia with one antero-dorsal bristle.

This species appears to be confined to the southern Nearctic and northern Neotropical regions.

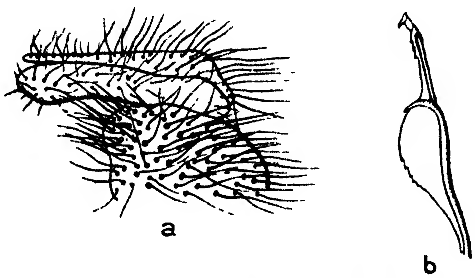
Lucilia eximia (Wied.).

**Musca eximia* Wied., Zool. Mag. p. 53 (1819); Ausser. zweifl. Ins. ii, p. 399 (1830).
**Musca ochricornis* Wied., *part.*, Ausser. zweifl. Ins. ii, p. 408 (1830).
Lucilia ruficornis Macq., Mém. Soc. Roy. Agric. Arts Lille, p. 326 (1846); Dipt. exot. Suppl. i, p. 198 (1846).
**Lucilia punctipennis* Macq., Mém. Soc. Roy. Agric. Arts Lille, p. 216 (1848); Dipt. Exot. Suppl. iii, p. 56 (1848).
**Musca insularis* Walk., Ins. Saund. iv, p. 340 (1852).
**Somomyia sylphida* Big., Ann. Soc. Ent. Fr. (5) vii, p. 45 (1877).
**Somomyia mutabilis* Big., Ann. Soc. Ent. Fr. (5) vii, p. 248 (1877).
**Somomyia pueblensis* Big., Ann. Soc. Ent. Fr. (5) vii, p. 250 (1877).
**Somomyia orenoquina* Big., Ann. Soc. Ent. Fr. (5) vii, p. 253 (1877).
**Somomyia amazona* Big., Ann. Soc. Ent. Fr. (5) vii, p. 255 (1877).
Lucilia hirtiforceps Snn., Proc. Ent. Soc. Wash. xxviii, p. 153 (1926).

Distribution.—Southern North America, West Indies, Central and S. America.

♂♀.—*Head.* Eyes separated, in male by distance equal to width of third antennal segment, in female by one-quarter total head-width; parafrontals in

TEXT-FIG. 29



Genitalia of *Lucilia eximia*, × 52.
a, forceps, lateral view; *b*, penis, lateral view.

male contiguous for a short space, in female each equal in width to one-half of frons, covered with silvery-gold tomentum; frons in male obliterated for a short space, in female parallel-sided, brownish black, shining blue-green at vertex, reddish above point of insertion of antennae; parafacials, face, and jowls covered with golden tomentum, the margin of the epistome testaceous, antennae orange to brown, frequently particoloured; palpi orange.

Thorax. Shining green to purple, silver-dusted anteriorly; two postsutural acrostichal bristles.

Abdomen. Shining green to purple; male hypopygium inconspicuous; male genitalia characteristic, the forceps slim and hairy (text-fig. 29).

Wings. Hyaline; basicostal scale dark brown; subcostal sclerite covered

with decumbent brown pubescence; squama in male light brown, in female white; halteres orange.

Legs. Dark brown; middle tibia with one antero-dorsal bristle.

L. eximia Wied. is the commonest and most widely spread of the S. American species. The unique type is a female in the Vienna Museum, and the two female cotypes of *L. ochricornis* (Wied.) also belong to *L. eximia*. There are also some specimens in the Vienna Museum determined by Wiedemann as *Musca putrida* F.; some of these are *L. eximia* and the remainder *L. cchricornis*, but it is impossible to settle the identity of Fabricius's species without examining his type-specimen.

LUCILIA RICA Snn.

Lucilia rica Snn., Proc. Ent. Soc. Wash. xxviii, p. 132 (1926).

Distribution.—Antigua. West Indies: Porto Rico.

♂♀.—*Head*. Eyes in male closely approximated, anterior facets slightly enlarged, in female separated by distance equal to one-quarter total width of head; parafrontals in male touching for a short distance, reduced to two fine lines, in female each parafrontal equal to one-half width of frons, silver-dusted in both sexes; frons black, obliterated for a short distance in male, parallel-sided in female; parafacials, face, and jowls grey-dusted; antennae brown to brownish orange; palpi orange.

Thorax. Shining blue-green, lightly silver-dusted anteriorly; two postsutural acrostichal bristles.

Abdomen. Shining blue-purple; male hypopygium inconspicuous; genitalia very similar to those of *L. eximia* Wied.

Wings. Hyaline, grey-tinted; basicostal scale brown; subcostal sclerite covered with sparse brown decumbent pubescence; squama in male brown, in female dirty white; halteres brownish yellow.

Legs. Dark brown, middle tibia with one antero-dorsal bristle.

It is possible that *Somomyia soulouquina* Big. and *S. semiviolacea* Big., both described from specimens taken in the West Indies, belong to this species. The types, however, are females and in very bad condition, rendering certain determination impossible. The type of Robineau-Desvoidy's species *L. azurea* is in the Paris Museum. It was redescribed by Séguy (1928); the locality on the label is Saint-Sever (Landes). After examining the specimen, I have come to the conclusion that it belongs to one of the S. American species. The specimen seems to me to approximate most closely to *L. rica*, but as there is a certain amount of doubt as to the locality from which the specimen originated I hesitate to use the name *azurea* for *L. rica* Snn. Bezzi, in the 'Palaearctic Catalogue', places Robineau-Desvoidy's name as a synonym of *L. caesar* (L.).

LUCILIA IBIS Snn.

Lucilia ibis Snn., Proc. Ent. Soc. Wash. xxviii, p. 132 (1926).

Distribution.—Peru.

♂♀.—*Head.* Eyes in male closely approximated, anterior facets slightly enlarged, in female separated by distance equal to rather less than one-quarter total head-width; frons in male partly obliterated, in female twice to three times width of one parafrontal, black, slightly reddish above antennae; parafrontals in male contiguous for a short distance, reduced to two fine lines, in female metallic blue-green for one-third of their length from vertex downwards, thence silver-dusted; parafacials and jowls silver-grey dusted, often reddish in appearance; antennae dark brown, lighter at base of third segment; palpi orange.

Thorax. Shining blue-green to purple, two postsutural acrostichal bristles; chaetotaxy well developed.

Abdomen. Shining blue-green to purple, the posterior margins of the segments sometimes dark-banded; male genitalia very similar to those of *L. eximia* (Wied.).

Wings. Grey, hyaline, more or less indefinitely infuscated towards base and very slightly clouded along the costa; basicosta dark brown; subcostal sclerite covered with soft brown decumbent pubescence; squama dark brown in both sexes.

Legs. Black: middle tibia with one antero-dorsal bristle.

I have not seen the types of this species, but have redescribed it from a series of specimens which appear to agree fairly well with Shannon's original description.

LUCILIA OCHRICORNIS (Wied.).

**Musca ochricornis* Wied., *part.*, Ausser. Zweifl. Ins. ii, p. 408 (1830).

**Lucilia subrectinevris* Macq., Mém. Soc. Sci. Agric. Arts Lille, p. 223 (1851); Dipt. Exot. Suppl. iv, p. 250 (1851).

Distribution.—Brazil, Argentina.

♂♀.—*Head.* Eyes in male separated by distance equal to one-half or rather more than one-half width of third antennal segment, in female by one-quarter total width of head; frons in male obliterated for a short space, in female parallel-sided, reddish black to black, metallic blue green at vertex; parafrontals in male contiguous for a short distance, much narrowed towards vertex, in female one parafrontal equal to half width of frons, silver-dusted in both sexes; parafacials, face, and jowls silver-dusted, the colour sometimes becoming golden reddish around the epistome; antennae dark brown, sometimes deep orange, second segment slightly reddish; palpi orange.

Thorax. Shining bluish green to purple; two postsutural acrostichal bristles; chaetotaxy well developed.

Abdomen. Shining blue-green to purple; posterior margin of second visible segment with rather long marginal bristles lying flat on third visible segment; male hypopygium inconspicuous, genitalia very similar to those of *L. eximia* (Wied.).

Wings. Hyaline, very slightly darkened at the base; basicostal scale dark brown to black, subcostal sclerite with dark brown decumbent pubescence; squama dark brown in both sexes.

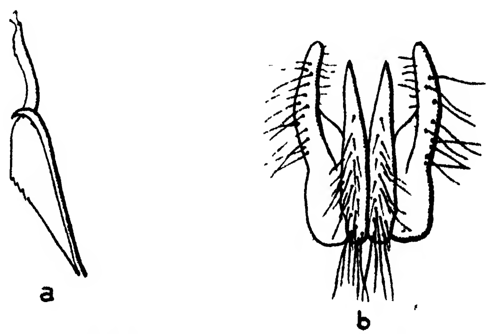
The male type of this species is in the Vienna Museum, and there are two further males and a series of females in the Berlin Museum. Two specimens among the latter sex have white squamae, and may be considered to belong to *L. eximia* (Wied.).

LUCILIA PURPURASCENS (Walk.).

**Musca purpurascens* Walk., Trans. Linn. Soc. xvii, p. 355 (1836).
**Lucilia brunnicornis* Macq., Mém. Soc. Sci. Agric. Arts Lille, p. 299 (1843); Dipt. Exot. ii, pt. 3, p. 142 (1843).
**Lucilia violacea* Macq., *nec* Gimm., Mém. Soc. Sci. Agric. Arts Lille, p. 99 (1847); Dipt. Exot. Suppl. ii, p. 83 (1847).
**Somomyia pallidibasis* Big., Ann. Soc. Ent. Fr. (5) vii, p. 247 (1877).
? *Lucilia praescia* G.-T., Boll. Mus. Torino viii, no. 147, p. 4 (1893).
Lucilia ocularis Snn., Proc. Ent. Soc. Wash. xxviii, p. 132 (1926).

Distribution.—N. America: Mexico, Costa Rica. S. America: Brazil, Guatemala, Bolivia, Peru, Venezuela, Colombia, Argentina.

TEXT-FIG. 30.



Genitalia of *L. purpurascens*, × 60.
a, penis, lateral view; *b*, forceps, dorsal view.

♂♀.—***Head***. Eyes in male completely contiguous for a short space, the upper anterior facets rather larger than the lower and posterior ones; in female eyes separated by rather more than one-fifth of head-width; parafrontals and parafacials reddish with slight silvery tomentum, the former bare except for the frontal bristles; antennae dull light brown, lighter at base of third segment; palpi yellow.

Thorax. Dark purple, dusted anteriorly; two postsutural acrostichal bristles. Pro- and post-thoracic spiracles brown, somewhat enlarged.

Abdomen. Dark purple; genitalia as in text-fig. 30, inconspicuous.

Wings. Hyaline; costal, proximal part of subcostal, and basal cells heavily infuscated (the degree of infuscation varies, however); basicostal scale dark brown to black; subcostal sclerite with decumbent dark brown pubescence; squama deeply infuscated.

Legs. Dark brown; middle tibia with one antero-dorsal bristle.

This is a striking and easily recognizable species; apart from the types examined, I have seen specimens of *L. ocularis* Snn. determined by Aldrich after comparison with the type; all the species identified by v. der Wulp in the 'Biologia Centrali-Americana' as *Calliphora praescia* G.-T. belong here.

List of names which have, at one time or another, been associated with the genus *Lucilia*.†

accincta Wied. (*Musca*), Brauer and v. Bergenstamm (1891) place this species in *Lucilia*, presumably having seen the type; probably a *Phormia*.

**albipennis* Meig. (*Musca*), not a *Lucilia*, although given as a synonym of *L. caesar* L. in 'Palaearctic Catalogue'.

**anchorata* Big. (*Somomyia*), a synonym of *Chrysomyia chloropyga* Wied., according to a label on the type in Villeneuve's handwriting.

anulipes Rond. (*Lucilia*), probably not a *Lucilia*.

**arcuata* Macq. (*Lucilia*), a synonym of *Chrysomyia albiceps* Wied., *part.*, and *Chrysomyia putoria* Wied., *part.*

**argenticeps* Macq. (*Lucilia*), a synonym of *Hemipyrellia cyanea* F

**argentifera* Big. (*Somomyia*), a synonym of *Orthellia caesarion* Mg., not of *L. cornicina*.

argentina Big. (*Somomyia*), type apparently lost.

**assiniensis* Big. (*Lucilia*), a synonym of *Hemipyrellia fernandica* Macq. (Aubertin, 1931).

**atrifacies* Big. (*Somomyia*), a synonym of *Orthellia coerulea* Wied. (Aubertin, 1933).

**aztequina* Big. (*Somomyia*), belongs to the subfamily *Chrysomiinae*.

ballardi Patt. (*Lucilia*), a synonym of *Hemipyrellia ligurriens* Wied.? (Aubertin, 1931).

**barbata* Big. (*Somomyia*), a synonym of *Chrysomyia rufifacies* Macq.

**barbigera* Big. (*Somomyia*), a synonym of *Chrysomyia chloropyga* Wied. according to a label on the type in Villeneuve's handwriting.

basifera Walk. (*Lucilia*), type missing; probably not a *Lucilia*.

**bengalensis* R.-D. (*Lucilia*), a synonym of *Orthellia lauta* Wied. (Aubertin, 1933).

**bipuncta* Wied. (*Musca*), a *Pyrellia*, not a *Lucilia* as suggested by Jaennicke (1867).

birmanensis Big. (*Somomyia*), type missing; probably not a *Lucilia*.

bivittata Dol. (*Lucilia*), a *Calliphora* according to van der Wulp (1896).

**boersiana* Big. (*Somomyia*), a good species of *Orthellia* (Aubertin, 1933).

**borbonensis* Macq. (*Lucilia*), a synonym of *Hemipyrellia cyanea* F. (Aubertin, 1931).

brevigaster Macq. (*Lucilia*), probably not a *Lucilia*.

**brunnipes* Macq. (*Lucilia*), a synonym of *Hemipyrellia cyanea* F. (Aubertin, 1931).

† An asterisk indicates that the type-specimen has been examined by the author.

**caeruleifrons* Macq. (*Lucilia*), an *Orthellia* (Aubertin, 1933).

**caeruleocincta* Big. (*Somomyia*), a synonym of *Strongyloneura delectans* Walk. *apud* Senior-White *in litt.*

**caeruleolimbata* Big. (*Somomyia*), a synonym of *Hemipyrellia ligurriens* Wied. (Aubertin, 1931).

caeruleovirens Rond. (*Compsomyia*), possibly a *Lucilia*.

**caffra* Big. (*Somomyia*), a synonym of *Orthellia boersiana* Big. (Aubertin, 1933).

**callipes* Big. (*Somomyia*), belongs to the subfamily *Chrysomyiinae*.

**carolinensis* R.-D. (*Lucilia*), a synonym of *Orthellia caesarion* Mg., not *O. cornicina* as given by Aldrich (1905).

**chloris* Hal. (*Lucilia*), a synonym of *Orthellia caesarion* Mg. (Aubertin, 1933).

coerulea Wied. (*Musca*), an *Orthellia*, not a *Lucilia* as given by Senior-White (1926).

compar R.-D. (*Lucilia*), a synonym of *Orthellia cornicina* Mg. according to Hough (1899).

curvipes Thoms. (*Lucilia*), not a *Lucilia*.

**cyaneocincta* Big. (*Somomyia*), a synonym of *Chrysomyia megacephala* F.

**ditissima* Walk. (*Musca*), belongs to the subfamily *Rhiniinae*.

**dives* Big. (*Somomyia*), a synonym of *Chrysomyia megacephala* F.

durvillei Macq. (*Lucilia*), a *Chrysomyia*, according to Brauer (1899).

dux Eschh. (*Musca*), a *Chrysomyia* according to many authors.

**elegans* Macq. (*Lucilia*), a synonym of *Chrysomyia chloropyga* Wied. (Brauer, 1899).

esmeralda Big. (*Somomyia*), type apparently missing.

**eximia* R.-D., *nec* Wied. (*Lucilia*), a synonym of *Orthellia lauta* Wied. (Aubertin, 1933).

fasciata Macq. (*Lucilia*), a *Chrysomyia* (Austen, 1906).

fergusoni Patt. (*Lucilia*), a *Hemipyrellia* (Malloch, 1927).

**fernandica* Macq. (*Lucilia*), a *Hemipyrellia* (Aubertin, 1931).

**flavicalyptrata* Macq. (*Lucilia*), an *Orthellia* (Aubertin, 1933).

flaviceps Macq. (*Lucilia*), a *Chrysomyia* (Austen, 1906).

flavidipennis Macq. (*Lucilia*), probably an *Orthellia*.

**flavigena* Big. (*Somomyia*), belongs to the subfamily *Chrysomyiinae*.

**fortunata* Walk. (*Musca*), a synonym of *Hemipyrellia ligurriens* Wied. (Aubertin, 1931).

**fulvicornis* Big., *nec* R.-D. (*Lucilia*), Villeneuve (1926) places this species in the genus *Phumosia*, subgenus *Stenophumosia*.

fulvicornis R.-D., *nec* Big. (*Lucilia*), possibly a *Lucilia*.

**fulvinota* Big. (*Somomyia*), belongs to subfamily *Chrysomyiinae*.

fulvipes Lw. (*Lucilia*), not a *Lucilia*.

fuscanipennis Macq. (*Lucilia*), a *Chrysomyia* according to Brauer (1899).

fuscipennis F. (*Musca*), not a *Lucilia*, from the description.

**fuscocincta* Big. (*Somomyia*), belongs to subfamily *Rhiniinae*.

germana R.-D. (*Lucilia*), probably a *Phormia*.

gratiosa Big. (*Somomyia*), type apparently missing.
guineensis Wied. (*Musca*), possibly an *Orthellia*.
**heraea* Walk. (*Musca*), a synonym of *Orthellia caesarion* Mg. (Aubertin, 1933).
hyacinthina R.-D. (*Lucilia*), according to Hough (1900), a synonym of *Hemilucilia segmentaria* F.
**incisuralis* Macq. (*Lucilia*), a *Chrysomyia*.
**indica* R.-D. (*Lucilia*), an *Orthellia* (Aubertin, 1933).
**infumata* Big. (*Somomyia*), type-specimen so damaged as to be unrecognizable, probably not a *Lucilia*.
**intrahens* Walk. (*Musca*), a synonym of *Orthellia coerulia* Wied. (Aubertin, 1933).
**inventrix* Walk. (*Lucilia*), Malloch (1923) has made this species the genotype of *Pyrellina*.
leonardi Weyenb. (*Lucilia*), probably not a *Lucilia*.
**ligurriens* Wied (*Musca*), a *Hemipyrellia* (Aubertin, 1931).
luteicornis Jaenn. (*Lucilia*), type missing; according to Brauer and von Bergenstamm (1893), a *Lucilia*.
**madagascariensis* Macq. (*Lucilia*), a synonym of *Hemipyrellia cyanea* F. (Aubertin, 1931).
**marginata* Macq. (*Lucilia*), according to Séguy (1928)=*Chrysomyia albiceps* Wied., probably a *Chrysomyia*.
**melanifera* Big. (*Somomyia*), a synonym of *Chrysomyia rufifacies* Macq. (Bezzi, 1927).
**melanorhina* Big. (*Somomyia*), an *Orthellia*.
mera Snn. (*Lucilia*), a *Lucilia*, but cannot place it with certainty.
meridensis Macq. (*Lucilia*), according to Brauer (1899) a *Pyrellia*.
**micropogon* Big. (*Somomyia*), a synonym of *Chrysomia rufifacies* Macq. (Does not belong to the *C. megacephala* group.)
**mollis* Walk. (*Musca*), type a headless female; a *Lucilia*, but unidentifiable.
**montevidensis* Big. (*Somomyia*), belongs to the subfamily *Chrysomyiinae*.
morilli Towns. (*Lucilia*), according to Tothill (1913), a synonym of *Orthellia cornicina* Mg.
munda Wied. (*Musca*), belongs to subfamily *Rhiniinae*.
nigriceps Macq. (*Lucilia*), probably not a *Lucilia*.
**nigrina* Big. (*Somomyia*), a species of *Phormia*.
nigrocoerulea Macq. (*Lucilia*), probably not a *Lucilia*.
**nigrofasciata* Macq. (*Lucilia*), a synonym of *Chrysomyia albiceps* Wied., *part*., and *Chrysomyia putoria* Wied., *part*.
**nitidifacies* Big. (*Somomyia*), a synonym of *Orthellia chalybea* Wied. (Aubertin, 1933).
**nubiana* Big. (*Somomyia*), a synonym of *Chrysomyia albiceps* Wied.
nubipennis Rond. (*Lucilia*), according to Hough (1900), a synonym of *Hemilucilia segmentaria* F.
occidentalis Snn. (*Lucilia*), a *nomen nudum*.

orientalis Macq. (*Lucilia*), a synonym of *Chrysomyia rufifacies* Macq.

**pagodina* Big. (*Somomyia*), a *Hemipyrellia* (Aubertin, 1931).

parensis Macq. (*Lucilia*), possibly a *Lucilia*, but not *L. caesar* L. (Hough, 1900); perhaps *L. ochricornis* Wied.

pavonina Schin. (*Lucilia*), not a *Lucilia*.

**peronii* R.-D. (*Lucilia*), an *Orthellia* (Aubertin, 1933).

peruviana R.-D. (*Lucilia*), probably not a *Lucilia*.

**pfeifferi* Big. (*Somomyia*), a synonym of *Chrysomyia megacephala* F. according to a note on the type in Villeneuve's handwriting. Also Patton (1925).

**phellia* Walk. (*Musca*), a synonym of *Hemipyrellia pulchra* Wied. (Patton, 1922 *a*).

philippensis Macq. (*Lucilia*), very probably an *Orthellia*.

picicrus Thoms. (*Lucilia*), not a *Lucilia*.

**pictifacies* Big. (*Somomyia*), belongs to subfamily *Rhiniinae*.

**pinguis* Walk. (*Lucilia*), a *Chrysomyia* (Aubertin, 1932).

porticola Thoms. (*Lucilia*), not a *Lucilia*.

primaveris Snn. & del Ponté (*Lucilia*), a *Lucilia*, but cannot place it with certainty.

princeps Rond. (*Lucilia*), probably a *Lucilia*, but not *L. caesar* L. as suggested by Hough (1900).

pubens Macq. (*Lucilia*), may be a *Lucilia*.

**puella* Mg. (*Musca*), a synonym of *Orthellia caesarion* Mg. (Aubertin, 1933).

**pulchra* Wied. (*Musca*), a *Hemipyrellia* (Malloch, 1926).

**punctifera* Big. (*Somomyia*), a synonym of *Chrysomyia putoria* Wied. according to a label on the type in Villeneuve's handwriting.

quadrisignata Thoms. (*Lucilia*), not a *Lucilia*.

quieta G.-T. (*Lucilia*), probably a *Lucilia*.

**rectinervis* Big. (*Somomyia*), an unidentifiable *Lucilia*.

**rectinevris* Macq. 1851, *nec* 1855 (*Lucilia*), an unrecognizable *Lucilia*.

**rectinevris* Macq. 1855, *nec* 1851 (*Lucilia*), a synonym of *Orthellia peronii* R.-D., *part.*, & *Lucilia*, *part.* (headless).

**rubiginosa* Big. (*Somomyia*), a synonym of *Strongyloneura dotata* Walk. *apud* Senior-White *in litt.*

**rubrifrons* Macq. (*Lucilia*), belongs to the subfamily *Chrysomiinae*.

ruficeps Macq., *nec* Meig. (*Lucilia*), very probably belongs to subfamily *Rhiniinae*.

**ruficornis* Macq. 1847, *nec* 1846 (*Lucilia*), a synonym *Hemipyrellia pulchra* Wied. (Patton, 1922).

**rufigena* Big. (*Somomyia*), 1 male cotype, a synonym of *Phormia regina* Mg. (Hough, 1899); 1 male and 1 female cotype *Myiophasia metallica* Towns., *apud* Aldrich *in litt.*

rufipalpis Jaenn. (*Lucilia*), type apparently missing; according to Brauer and von Bergenstamm (1893) a *Calliphora*, according to Hough (1899) a synonym of *Phormia regina* Mg.

**rupicola* Big. (*Somomyia*), a synonym of *Phormia regina* Mg. (Hough, 1899).
**saffranea* Big. (*Somomyia*), a synonym of *Chrysomyia megacephala* F. (Patton, 1925).
senegalensis Macq. (*Lucilia*), may be a *Lucilia*.
**smaragdosaphira* Big. (*Lucilia*), a synonym of *Hemipyrellia cyanea* F. (Villeneuve, 1915).
smaragdula R.-D. (*Lucilia*), possibly *Lucilia eximia* Wied.
**solaia* Walk. (*Musca*), a synonym of *Hemipyrellia ligurriens* Wied. (Aubertin, 1931).
spekei Jaenn. (*Lucilia*), type apparently missing; according to Brauer and von Bergenstamm (1893), a *Pyrellia*.
spinicosta Hough (*Lucilia*), belongs to "*Lucilia sericata*" group.
stigmaticalis Thoms. (*Lucilia*), according to Hough (1899) a synonym of *Phormia regina* Mg.
**surrepens* Walk. (*Lucilia*), a *Pyrellia*.
taeniaria Thoms. (*Lucilia*), not a *Lucilia*.
taeniata Big. (*Somomyia*), a *Chrysomyia*.
**taeniops* Big. (*Lucilia*), a synonym of *Hemipyrellia fernandica* Macq., *part.*, and of *H. cyanea* F., *part.* (Villeneuve, 1915).
**tagaliana* Big. (*Somomyia*), a *Hemipyrellia* (Aubertin, 1931).
**tasmaniensis* Macq. (*Lucilia*), a synonym of *Chrysomyia rufifacies* Macq.
tegularia Wied. (*Musca*), probably not a *Lucilia*.
terrae-novae Macq. (*Lucilia*), according to Hough (1899) a synonym of *Phormia regina* Mg.
**testaceifacies* Macq. (*Lucilia*), synonym of *Chrysomyia albiceps* Wied.
**thalassina* Mg. (*Musca*), a synonym of *Phormia regina* Mg., not of *Lucilia silvarum* Mg. as given in the 'Palaearctic Catalogue'.
**timorensis* R.-D. (*Lucilia*), a synonym of *Orthellia coerulea* Wied. (Aubertin, 1933).
turbida Wied. (*Musca*), very probably a *Calliphora*.
varians Wied. (*Musca*), possibly a *Lucilia*.
**varipalpis* Macq. (*Lucilia*), according to Séguy (1928)=*Chrysomyia albiceps* Wied.
**varipes* Macq. (*Lucilia*), a *Chrysomyia*, subgenus *Microcalliphora*.
**versicolor* Big. (*Somomyia*), according to Senior-White *in litt.* a synonym of *Strongyloneura selecta* Walk.
violacea Gimm., *nec* Macq. (*Lucilia*), may be a *Lucilia*.
violaceinitens Rond. (*Compsomyia*), possibly a *Lucilia*.
virens Wied. (*Musca*), subfamily *Rhiniinae*.
**viridiceps* Macq. (*Lucilia*), a synonym of *Orthellia coerulea* (Aubertin, 1933).
**viridifrons* Macq. (*Lucilia*), female cotypes the same as *Orthellia indica* R.-D.; male cotypes the same as *Orthellia trita* Walk. (Aubertin, 1933).
vittata Macq. (*Lucilia*), not a *Lucilia*.
xanthomera Rond. (*Somomyia*), probably not a *Lucilia*.

List of Literature cited.

1905. Aldrich, J. M. Catalogue of N. American Diptera, ii.
1931. Aubertin, D. Proc. Zool. Soc. London, pp. 497–509.
1932. —— Ann. & Mag. Nat. Hist. (10) ix, p. 28.
1933. —— *Ibid.* xi, pp. 139–144.
1906. Austen, E. E. *Ibid.* (7) xvii, pp. 301–304.
1927. Bezzi, M. Bull. Ent. Res. xvii, pp. 236–238.
1907. ——, & Stein, P. Kat. Pal. Dipt. iii.
1859. Bigot, J. Ann. Ent. Soc. Fr. (3) vii.
1877. —— *Ibid.* (5) vii.
1887. —— Bull. Soc. Zool. Fr., p. 604.
1891. —— Ann. Ent. Soc. Fr. (5) lx.
1915. Bishop, F. C., & Laake, E. W. Journ. Ec. Ent., pp. 472–474.
1899. Brauer, F. Sitzungsb. Akad. Wiss. Wien, Abth. i, cviii, pp. 520–529.
1889. ——, und v. Bergenstamm, J. Denskchr. Akad. Wiss. Wien, lvi, p. 157.
1891. —— —— *Ibid.* lviii, p. 420.
1893. —— —— *Ibid.* lx, p. 122.
1894. —— —— *Ibid.* lxi, pp. 84–85.
1926. Collin, J. E. Trans. Ent. Soc. Lond. lxxiv, pp. 258–260.
1927. Curran, C. H. Amer. Mus. Nov. no. 248, p. 4.
1857. Doleschall, C. L. Nat. Tidschr. Ned. Ind. xiv. p. 413.
1858. —— *Ibid.* xvii, p. 111.
1867. v. Frauenfeld, G. Verh. Zool.-bot. Ges. Wien, xvii, p. 453.
1905. Froggatt, W. W. Agric. Gaz. N.S.W. xvi, pp. 16–22.
1922. —— Agric. Dept. N.S.W., Farmer's Bulletin, no. 144, pp. 5–32.
1893. Giglio-Tos. Boll. Mus. Torino, viii, no. 147, p. 4.
1842. Gimmerthal, B. P. Bull. Soc. Imp. Nat. Moscow, xv, p. 677.
1893. Girschner, E. Berl. Ent. Zeitschr. xxxviii, pp. 297–312.
1907. Herms, W. B. Journ. Exp. Zool. iv, pp. 45–83.
1928. —— Journ. Ec. Ent. xxi, pp. 720–729.
1908. Hesse, E. Biol. Centralbl. xxviii, pp. 753–758.
1930. Holdaway, F. G., & Evans, A. C. Nature cxxv, pp. 598–599.
1898. Hough, G. de N. Proc. Acad. Phil., pp. 177–178.
1899. —— Zool. Bull. ii, pp. 283–290.
1900. —— Kansas Quart. ix, pp. 203–232.
1900. Howard, L. O. Proc. Wash. Acad. ii, pp. 541–604.
1867. Jaennicke, F. Abh. Senck. Ges. vi, pp. 374–376.
1913. Johnson, C. W. Ann. Ent. Soc. Amer. vi, p. 448.
1910. Kramer, H. Ent. Rundsch. xxvii, pp. 34–35.
1911. —— Abhandl. Naturforsch. Ges. Görlitz xxvii, pp. 158–159.
1917. —— *Ibid.* xxviii, pp. 283–284.
1925. Lestage, J. A. Bull. & Ann. Soc. Ent. Belg. lxv, pp. 309–310.
1758. Linnaeus, C. Syst. Nat., Edn. x, pp. 400, 595.
1835. Macquart, M. J. Suites à Buffon ii, p. 251.
1843–1855. —— Diptères Exotiques.
1923. Malloch, J. R. Ann. & Mag. Nat. Hist. (9) xii, p. 525.
1924. —— Trans. N.Z. Institute lv, pp. 638–640.
1926. —— Ann. & Mag. Nat. Hist. (9) xvii, p. 503.
1927. —— Proc. Linn. Soc. N.S.W. lii, pp. 320–322.
1826. Meigen, J. W. Syst. Beschr. v.
1928. Mercier, L. Bull. Mens. Soc. Lin. de Normandie (8) i, p. 10.
1867. Moniez, R. Bull. Dep. Nord. Lille, viii, p. 25.

1887. OSTEN-SACKEN, C. R. Berl. Ent. Zeitschr. xxxi, pp. 17–28.
1896. PANDELLÉ, L. Rev. Entom. xv, p. 402.
1922. PATTON, W. S. Ind. Journ. Med. Res. ix, pp. 548–554, 572–574, 635–653.
1922 *a*. —— Bull. Ent. Res. xiii, p. 113.
1925. —— Phil. Journ. Sci. xxvii, pp. 177–193, 402–405.
1885. PORTCHINSKY, J. Hor. Soc. Ent. Ross. xix, pp. 210–244. (For English *résumé* see Osten-Sacken, 1887.)
1926. RICHARDS, O. W. Trans. Ent. Soc. Lond. lxxiv, pp. 255–257
1830. ROBINEAU-DESVOIDY, J. B. Les Myodaires, pp. 452–462
1863. —— Posth. ii, pp. 395, 750.
1925. ROHDENDORF, B. VON. Rev. Zool. Russe, iv, fasc. i.
1928. —— Ent. Mitt. xvii, pp. 337–338.
1861. RONDANI, C. Dipt. Ital. Prod. iv, pp. 9, 395.
1864. —— Arch. Zool. Anat. Fisiol. iii, p. 30.
1875. —— Ann. Mus. Genov. vii, pp. 425–426.
1868. SCHINER, J. R. Reise der Novara, Zool. Dipt., pp. 304–306.
1925. SÉGUY, E. Encyc. Ent. sér. B, ii, Dipt. 2, Fasc. 2, pp. 93–94.
1925 *a*. —— Bull. Soc. Path. Exot. xviii, p. 734.
1928. —— Encyc. Ent. sér. A, ix, pp. 145–161.
1926. SENIOR-WHITE, R. Rec. Ind. Mus. xxviii, pp. 130–131.
1924. SHANNON, R. C. Insec. Inscit. Mens. xii, pp. 34–36 & 67–81
1926. —— Proc. Ent. Soc. Wash. xxviii, pp. 115–133.
1926 *a*. ——, & DEL PONTÉ. Rev. Inst. Bact. Buenos Ayros iv, pp. 585–586
1929. SMIT, B. Bull. 47, Dept. Agr., Union of S. Africa.
1930. STADLER. Zeitschr. f. Parasitenk. ii, pp. 360–367.
1924. STEIN. Arch. Naturg. A. 6, pp. 262–263.
1868. THOMSON, C. G. Eugenies Resa, pp. 543–545.
1913. TOTHILL, J. S. Ann. Ent. Soc. Amer. vi, pp. 241–256.
1908. TOWNSEND, C. H. T. Smiths. Misc. Coll. ii, p. 121.
1919. —— Proc. U.S. Nat. Mus. lvi, p. 542.
1928. —— Ann. Soc. Ent. Amer. xxi, p. 121.
1896. van der WULP, F. M. Cat. Dipt. S. Asia, pp. 148–150
1903. —— Biol. Centr.-Amer., Dipt. ii, pp. 294–299.
1901. VERRALL, G. H. List Brit. Dipt., p. 27.
1914. VILLENEUVE, J. Feuill. Jeun. Nat. xliv, p. 95.
1914 *a*. —— Bull. Soc. Ent. Fr., p. 307.
1915. —— Rev. Zool. Afr. iv, pp. 205–206.
1922. —— Bull. Mus. Paris, xxviii, p. 515.
1926. —— Rev. Zool. Afr. xiv, p. 68.
1836. WALKER, F. Trans. Linn. Soc. xvii, p. 355.
1849. —— List Dipt. Brit. Mus. iv.
1850–56. —— Insecta Saundersiana, London.
1857. —— Journ. Proc. Linn. Soc. i, p. 24.
1859. —— *Ibid.* iii, p. 105.
1860. —— *Ibid.* iv, p. 136.
1861. —— *Ibid.* v, p. 302.
1819. WIEDEMAN, C. R. W. Zool. Mag., p. 53.
1830. —— Aussereur. Zweifl. Ins. ii.

INDEX

accincta Wied., 427.
alaskensis Snn., 394, 396, **398.**
albipennis Meig., 427.
albopilosa S.-W., 406.
Alysia (*Hym.*), 393.
amazona Big., 423.
amica R.-D., 412.
ampullacea Vill., 392, 396, **403.**
anchorata Big., 427.
angustifrons Tns., 400, 401.
anulipes Rond., 427.
arcuata Macq., 427.
argenticeps Macq., 427.
argentifera Big., 427.
argentina Big., 427.
Argoracrites, 395, 409.
argyricephala Macq., 413.
assiniensis Big., 427.
atrifacies Big., 427.
australis Tns., 421.
aztequina Big., 427.
azurea Dol., *nec* R.-D., 406.
azurea R.-D., *nec* Dol., 424.

ballardi Patt., 427.
barbata Big., 427.
barberi Tns., 411, 412.
barbigera Big., 427.
basalis Macq., 411, 412.
basifera Walk., 427.
bengalensis R.-D., 427.
Bergenstamm, von, 390.
Bigot, 390.
bipuncta Wied., 427.
birmanensis Big., 427.
Bishop, 393.
bivittata Dol., 427.
boersiana Big., 427.
borbonensis Macq., 427.
Brauer, 390.
brevicornis Ashm. (*Hym.*), 393.
brevigaster Macq., 427.
brunnicornis Macq., 426.
brunnicosa R.-D., 418, 419.
brunnipes Macq., 427.
Bufolucilia, **395**, 418, 419.
bufonivora Mon., 393, 394, 397, **419.**

caeruleifrons Macq., 428.
caeruleiviridis Macq., 397, **421.**
caeruleocincta Big., 428.
caeruleolimbata Big., 428.
caeruleovirens Rond., 428.
caerulia Ség., 396, **405.**
caesar L., 390, 395, 396, **400.**
caesar plur. auct., *nec* L., 402.
Caesariceps, **395**, 403.
caffra Big., 428.
callipes Big., 428.
Calliphora, 390.
calviceps Bezzi, 406, 407.
capensis R.-D., 411.
carolinensis R.-D., 428.
chloris Hal., 428.
Chrysomyia, 390.
cluvia Walk., 397, **418,** 422.
coerulia Wied., 428.
Collin, 391, 401.
compar R.-D., 428.
Compsomyia, 390.
consobrina Macq., 402.
craggii Patt., 408.
cuprina Wied., 393, 394, 397, **412.**
curvipes Thoms., 428.
cyaneocincta Big., 428.
cyaneo-marginata Macq., 406, 407

Dasylucilia, **395.**
ditissima Bezzi, *nec* Walk., 399.
ditissima Walk., *nec* Bezzi, 400, 428.
dives Big., 428.
dorsalis R.-D., 412.
durvillei Macq., 428.
dux Eschh., 428.

elegans Macq., *nec* R.-D., 428.
elegans R.-D., *nec* Macq., 413.
elongata Snn., 419, 421.
equestris Mg., 402.
esmeralda Big., 428.
eximia R.-D., *nec* Wied., 428.
eximia Wied., *nec* R.-D., 394, 395, 398, **423.**

fasciata Macq., 428.
fergusoni Patt., 428.
fernandica Macq., 428.
flavicalyptrata Macq., 428.
flaviceps Macq., 428.
flavicornis Mall., 397, **410.**
flavidipennis Macq., 428.
flavigena Big., 428.
flavipennis Kram., *nec* Macq., 403.
flavipennis Macq., *nec* Kram., 404, 411, 412.
fortunata Walk., 428.
Francilia, 392, 395, 398.
fraterna Macq., 402.
Froggatt, 393.
frontalis Lw., 411.
fucina Walk., 413.
fulvicornis Big., *nec* R.-D., 428.
fulvicornis R.-D., *nec* Big., 428.
fulvinota Big., 428.
fulvipes Lw., 428.

fumicosta Mall., 392, 396, **399.**
fuscanipennis Macq., 428.
fuscipennis F., 428.
fuscocincta Big., 428.

germana R.-D., 429.
giraulti Tns., 411, 412.
GIRSCHNER, 390.
graphita Snn., 394, 396, **410.**
gratiosa Big., 429.
guineensis Wied., 429.

Hemipyrellia, 391, 407.
heraea Walk., 429.
HERMS, 393.
hirtiforceps Snn., 423.
HOLDAWAY, 393.
HOUGH, 391.
HOWARD, 393.
hyacinthina R.-D., 429.

ibis Snn., 395, 398, **424.**
ignita R.-D., 417.
illustris, 179, 392, 393, 394, 396, **402.**
incisuralis Macq., 429.
indica R.-D., 429.
inducta Walk., 406.
infernalis Vill., 392, 396, **404.**
infumata Big., 429.
infuscata Tns., 422.
inscribens Walk., 406.
insularis Walk., 423.
intrahens Walk., 429.
inventrix Walk., 429

japonica Big., 408, 409.
jeddensis Big., 400.

KRAMER, 391.
krameri Ség., 403, 404.

LAAKE, 393.
lagyra Walk., 411.
leonardi Weyenb., 429.
lepida R.-D., 402.
leucodes Frauenf., 413, 414.
ligurriens Wied., 429.
longilobata Pand., 414, 415.
Lucilia, 395.
Luciliella, 392, **395.**
lucilioides v. der Wulp, 418.
luteicornis Jaenn., 429.

MACQUART, 390.
madagascariensis Macq., 429.
MALLOCH, 391, 392, 401.
manducator Panz. (*Hym.*), 393.
marginata Macq., 429.
marginifera Walk., 406.
MEIGEN, 390.
melanifera Big., 429.
melanorhina Big., 429.
mera Snn., 429.
MERCIER, 420.
meridensis Macq., 429.
metilia Walk., 406.
mexicana Macq., 398, **422.**
micropogon Big., 429.
mollis Walk., 429.
montevidensis Big., 429.
morilli Towns., 429.
munda Wied., 429.
muralis Walk., 402.
Musca, 390.
Muscae nobiles, 390.
mutabilis Big., 423.

Nansonia (*Hym.*), 393.
nebulosa Big., 406, 407, 408.
nigriceps Macq., 429.
nigricosta Mall., 392, 405, 406.
nigrina Big., 429.
nigripalpis Tns., 418, 419.
nigrocaerulia Macq., 429
nigrofasciata Macq., 429
nitescens Walk., 406.
nitidifacies Big., 429.
nobilis Mg., 411.
nosocomiorum Dol., 406, 407.
nubiana Big., 429.
nubipennis Rond., 429.

obesa Big., 408, 409.
occidentalis Snn., 430.
ochricornis Wied., 394, 398, **425.**
ochricornis Wied., 423, 424.
ocularis Snn., 426, 427.
oculata Tns., 421.
orenoquina Big., 423.
orientalis Macq., 430
Orthellia, 390.

pachymosa Patt., 408.
pachysoma Big., 408.
pagodina Big., 430.
pallescens Snn., 413.
pallidibasis Big., 426.
pallifrons Big., 413.
papuensis Macq., 394, 396, **406.**
parensis Macq., 430.
parvula Mg., 402, 403.
PATTON, 391.
pavonina Schin., 430
peronii R.-D., 430.
peruviana R.-D., 430.
pfeifferi Big., 430.
Phaenicia, 392, **395.**
phellia Walk., 430.
philippensis Macq., 430.
Phormia, 390.
Phumonesia, **395,** 405.
picicrus Thoms., 430.
pictifacies Big., 430.
pilatei Hough, 418.
pilosiventris Kram., *nec* Richards, 397, **415.**
pilosiventris Richards, *nec* Kram., 416, 417.
pinguis Walk., 430.
pionia Walk., 392, 394, 396, **399.**
porphyrina Walk., 394, 396, 407, **408.**

PORTCHINSKY, 393.
porticola Thoms., 430.
praescia G. T., 426, 427.
primaveris Snn. & del Ponté. 430.
princeps Rond., 430.
problematica Johns., 418.
pubens Macq., 430.
pueblensis Big., 423.
puella Mg., 430.
pulchra Wied., 430.
punctifera Big., 430.
punctipennis Macq., 423.
purpurascens Walk., 394, 395, 398, **426**.
purpurea Tns., 402.
putrida F., 424.
Pyrellia, 390.

quadrisignata Thoms., 430.
quieta G.-T., 430.

rectinervis Big., 430.
rectinevris Macq., 1851, *nec* 1855, 430.
rectinevris Macq., 1855, *nec* 1851, 430.
regalis Mg., 397, **414**, 419.
rica Snn., 394, 395, 398, **424**.
RICHARDS, 391.
richardsi Coll., 397, **416**.
ROBINEAU-DESVOIDY, 390.
ROHDENDORF, 392.
Roubaudiella, **395**, 405.
rubiginosa Big., 430.
rubrifrons Macq., 430.
ruficeps Macq., *nec* Meig., 430.
ruficornis Macq., 1846, *nec* 1847, 423.
ruficornis Macq., 1847, *nec* 1846, 430.
rufigena Big., 430.
rufipalpis Jaenn., 431.
rupicola Big., 431.
rutescens Patt., 406.

saffranea Big., 431.
sayi Jaen., 411.
SÉGUY, 391, 393.
semiviolacea Big., 424.
senegalensis Macq., 431.
serenissima Walk., 413.
sericata Mg., 392, 393, 394, 397, **411**.
SHANNON, 391, 392.
silvarum Mg., 393, 394, 397, 403, **418**.
simulatrix Pand., 402.
sinensis Aub., 396, **407**.
smaragdosaphira Big., 431.
smaragdula R.-D., 431.
SMIT, 393, 412.
solaia Walk., 431.
Somomyia, 390, **395**, 407.
soulouquina Big., 424.
spekei Jaenn., 431.
spinicosta Hough, 431.
splendida Mg., *nec* Verr., 400, 401.
splendida Verr., *nec* Mg., 416.
STADLER, 393.
STEIN, 391.
stigmaticalis Thoms., 431.
subrectinevris Macq., 425.
surrepens Walk., 431.
sylphida Big., 423.

taeniaria Thoms., 431.
taeniata Big., 431.
taeniops Big., 431.
tagaliana Big., 431.
tasmaniensis Macq., 431.
tegularia Wied., 431.
temperata Walk., 413.
terrae-novae Macq., 431.
testaceifacies Macq., 431.
thalassina Mg., 431.
thatuna Snn., 397, **417**.
tifata Walk., 406.
timorensis R.-D., 431.
turbida Wied., 431.

unicolor Tns., 422.

varians Wied., 431.
varipalpis Macq., 431.
varipes Macq., 431.
versicolor Big., 431.
villeneuvi Curr., 405.
violacea Gimm., *nec* Macq., 431.
violacea Macq., *nec* Gimm., 426.
violaceinitens Rond., 431.
virens Wied., 432.
viridiceps Macq., 432.
viridifrons Macq., 432.
Viridinsular, 392, **395**, 399.
vittata Macq., 432.

WIEDEMAN, 390.
WULP, van der, 390.

xanthomera Rond., 432.

Miocene Primates from Kenya.

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(PLATE 6)

[Read 26 October 1933]

I. INTRODUCTION.

Several years ago, Mr. E. J. Wayland, Director of the Geological Survey of Uganda, sent to the Geological Department of the British Museum a small collection of fossils which he had received from Dr. H. L. Gordon of Koru, Kenya Colony. Dr. Gordon had found them on the surface of a kopje which he was quarrying for agricultural lime. Among them was a nodule which revealed the tip of a canine tooth. On development the enclosed fossil proved to be the left maxilla of a large anthropoid ape with the cheek-teeth almost unworn. Since the fossils were weathering out of beds presumed to be of Lower Miocene age, this specimen was obviously of great interest and importance. In view of the possibility of obtaining more fossils, it seemed better to refrain from publication in the hope that later consignments might contain additional specimens of Primates.

These hopes were not realised until August 1931, when I visited Koru on behalf of the Trustees of the British Museum. During the five weeks that I was in camp nine more fragments of primate dentitions, as well as a rich and varied fauna of lower mammals, were recovered. All the bones had been broken before burial, and gnawed by rodents as they lay on the surface.

The fauna consists of two or three genera, which may prove to be lemuroids, *Dinotherium hobleyi*, three genera of Creodonts, an amphicyonine carnivore, several Rodents, two Insectivores—one very close to *Potamogale*,—as well as small pigs and ruminants.

The remains of higher primates are referred to three new genera of Simiidae, one of which is regarded as ancestral to the Chimpanzee. Both the others have become extinct.

II. SYSTEMATIC DESCRIPTION.

All the specimens are in the Department of Geology, British Museum (Natural History). The registered numbers refer to the departmental registers of fossil mammals.

Suborder CATARRHINA.

DIAGNOSIS.—P_2 missing. Dental formula $I\frac{2}{2}, C\frac{1}{1}, P\frac{2}{2}, M\frac{3}{3}$. Tympanic forming a bony external auditory meatus. No tympanic bulla. Generally

with a squamoso-frontal suture owing to the preponderance of the frontal and alisphenoid in the formation of the orbital plate. Orbito-temporal foramen small . . . . (Weber, 1904, p. 783).

Family *SIMIIDAE*.

Diagnosis.—Upper and lower molars quadritubercular, labial and lingual cusps alternating. Lower molars usually with a third labial cusp or a fifth cusp on the posterior margin. In the upper molars the labial cusps are more or less closely connected with the anterior lingual cusp; posterior lingual cusp usually smaller than the anterior. Premolars bicuspid, wider than long. (Adapted from Schlosser, 1923, p. 651.)

Genus *Limnopithecus* Hopwood.

1933. Ann. & Mag. Nat. Hist. (10) xi, p. 97.

Diagnosis.—Gibbon-like Simiidae with very low-crowned cheek-teeth in the lower jaw. Length-breadth index of lower molars exceeding 90. Lower molars with distinct external cingulum between the cusps.

Genotype.—*Limnopithecus legetet* Hopwood.

Limnopithecus legetet Hopwood. (Pl. 6. figs. 1, 2.)

1933. Ann. & Mag. Nat. Hist. (10) xi, p. 97.

Diagnosis.—As for the genus.

Holotype.—A fragment of the right mandibular ramus with the first and second molars partly worn. Regd. M 14079.

Paratype.—A piece of the left mandibular ramus with the two deciduous cheek-teeth, and with the left lateral incisor still in the crypt. Regd. M 14080.

Dimensions.—

Tooth dimension.	*L. legetet.* Holotype.	*L. legetet.* Paratype.	*Symphalangus* sp. Regd. 81.3.15.1. B.M. Zool. Dept.	*Hylobates lar.* Regd. 10.10.1.7. B.M. Zool. Dept.	*Hylobates leuciscus.* Regd. 9.1.5.2. B.M. Zool. Dept.
Dm3 : Length	..	4·5	..	..	3·8
Breadth	..	3·4	..	..	2·6
Height	..	2·8	..	..	2·4
Index	..	75·6	..	..	68·4
Dm4 : Length	..	5	..	..	4·6
Breadth	..	4·2	..	..	3·5
Height	..	2·1	..	..	2·4
Index	..	84	..	..	76·1

DIMENSIONS (*cont.*).—

Tooth dimension.		*L. legetet.* Holotype.	*L. legetet.* Paratype.	*Symphalangus* sp. Reg. 81.3.15.1. B.M. Zool. Dept.	*Hylobates lar.* Regd. 10.10.1.7. B.M. Zool. Dept.	*Hylobates leuciscus.* Regd. 9.1.5.2. B.M. Zool. Dept.
M1 :	Length	5·3	..	7·8	5·7	5·4
	Breadth	4·9	..	6·0	4·6	4·3
	Height..........	2·8	..	4·2	2·7	3
	Index	92·5	..	76·9	80·6	79·6
M2 :	Length	6·2 est.	..	9·8	6·2	..
	Breadth	6·0	..	6·5	5·1	..
	Height..........	2·8	..	4·5	3·2	..
	Index	96·8 est.	..	66·3	82·3	..

DESCRIPTION.—The holotype will be described first.

The body of the mandible has undergone extensive post-mortem deformation, with the result that the second molar is now about 3 mm. below the first. This gives the second molar the appearance of rising from the crypt to replace a lost deciduous tooth. But such is not the case, and, since the occlusal surface of the crown is worn, it is quite certain that the tooth has been displaced after death.

Each tooth is built on the same general plan of a basin with five cusps on the periphery, a basal cingulum between each cusp, with the possible exception of the two lingual cusps of the damaged first molar, and a small fovea anterior. The hypoconulid is median. Each cusp is low, blunt, rounded, and slightly worn at the top, so that the dentine is just exposed. The metaconid of the first molar and the protoconid and metaconid of the second molar have lost the peripheral enamel. Hence the teeth have a false appearance of an anterior narrowing.

The paratype is in perfect condition. It is deeper and heavier, but otherwise agrees fairly well with the corresponding region in a young female *Hylobates leuciscus* (B.M. Zool. Dept. 9.1.5.2). The symphysis extended back to the level of Dp3 ; the mental foramen is below the same tooth. Held with the alveolar margin horizontal, the bone narrows from in front backwards. The depth at the anterior end of Dp3 is 12 mm. ; at the posterior end of Dp4 it is 10 mm. ; the thickness is 5·5 mm. and 5 mm. at the same places.

The third deciduous premolar is not very compressed. It has a distinct metaconid separated from the protoconid by a deep notch representing the antero-posterior sulcus. The sharp antero-internal cingulum bounds a relatively large trigonid basin, or fovea anterior. The talonid basin is wide and deep.

The succeeding tooth (Dp4) is quinquecuspidate, wider behind than in front, and has anterior buccal and posterior basal cingula between the cusps. There is a definite crista transversa anterior, which, together with the anterior cingulum, bounds the fovea anterior. The hypoconulid resembles those of the second dentition in being central. When the tooth is viewed from the buccal or lingual aspects the trigonid and talonid are seen to be of equal height.

Discussion.—There are two fossil forms with which this species may be compared, namely, *Pliopithecus antiquus* Gervais and *Prohylobates tandyi* Fourteau. The former has a definite cingulum, the latter none at all; *Limnopithecus* has a slight cingulum which causes small foveae between all the cusps except the metaconid and entoconid. In this respect, therefore, the new species is intermediate between the European and Egyptian species. On the other hand, it agrees with *Prohylobates* and certain specimens of *Pliopithecus* (Mayet & Lecointre, 1909, p. 63; Remane, 1921, p. 151) in the median position of the hypoconulid.

In the genera which are still living, *Symphalangus* and *Hylobates*, there is no cingulum, except anteriorly, and the hypoconulid has become slightly buccal in position. In *Symphalangus* the metaconid shows a bifid tip. Moreover, the fossil has a greater breadth index :—

	M1.	M2.
Limnopithecus	92·5	96·8 est.
Hylobates	80·6	82·3
Symphalangus	76·9	66·3

This proves that *Hylobates* and *Limnopithecus* both differ from *Symphalangus* in having the second molar wider than the first—possibly, but not certainly, a sign of greater specialisation.

In its milk-dentition the fossil is more advanced than *Hylobates*. This is reflected in the well-marked metaconid of Dp3, the five cusps of Dp4 compared with the four found in *Hylobates*, and in the relative heights of the talonid and trigonid of Dp4, which are equal in *Limnopithecus* and unequal in *Hylobates*. Hence there can be no doubt that *Limnopithecus* and *Hylobates* are distinct genera.

Similarly, *Limnopithecus* and *Symphalangus* are distinct if to the differences previously mentioned be added the structure of the metaconid, which is simple in the former and bifid in the latter.

Pliopithecus and *Hylobates* are so much alike that Hoffmann (1893) united them. He showed that they agree, not only in the characters of the adults, but that the milk-dentitions are also alike in the absence of a hypoconulid on the posterior deciduous premolar. In this respect, therefore, *Limnopithecus* is distinct from *Pliopithecus*.

Other reasons for keeping the three fossil genera apart are the various ages of the deposits in which they are found and their widely separated

localities. Apart from convenience, neither reason is particularly sound, but, when dealing with species founded on such fragmentary remains as those of *Prohylobates tandyi* and *Limnopithecus legetet* there is much to be said in its favour. *Prohylobates* is from beds which Fourteau (1920) ascribed to the Burdigalian; *Pliopithecus* begins in the Aquitanian of Sansan and passes up to the top of the Miocene; but *Limnopithecus* occurs in beds of which the age is not definitely known. These beds are at present termed Lower Miocene, because they contain *Dinotherium hobleyi*. This species was first described from Karungu on the shore of Lake Victoria, and by analogy with European faunas the beds in which it was found were termed Lower Miocene (Andrews, 1914). Experience shows that European standards are apt to be misleading when applied to Africa, and that the age must be judged, not by survivors from the past such as the creodonts, nor by the presence of *Dinotherium*, but by the latest most advanced members of the fauna. Hence, apart from zoological considerations, it is convenient to give these fossils from Kenya a separate generic name.

The trivial name is that of the hill on whose slopes I had my camp, and in whose shadow the specimens were found.

Genus *Xenopithecus* Hopwood.

1933. Ann. & Mag. Nat. Hist. (10) xi, p. 97.

Diagnosis.—Simiidae in which ridges connect the protocone to the paracone, metacone, and hypocone; a fourth ridge connects the paracone and metacone. Cusps of trigon crowded, subequal in size. Hypocone large, but somewhat less than the cusps of the trigon. Anterior and posterior cingula distinct, internal cingulum massive. Enamel on lingual surface of the protocones wrinkled; elsewhere it is smooth.

Genotype.—*Xenopithecus koruensis* Hopwood.

Xenopithecus koruensis Hopwood. (Pl. 6. figs. 3, 4.)

1933. Ann. & Mag. Nat. Hist. (10) xi, p. 97.

Diagnosis.—As for the genus.

Holotype.—A fragment of the left maxilla with the partly worn first and second molars. Regd. M 14081.

Paratype.—A right upper posterior deciduous molar. Regd. M 14082.

Material.—In addition to the holotype and paratype, a broken mandibular symphysis with worn left third premolar. Regd. M 14083.

Dimensions.—

	Dp4.	M1.	M2.
Length	5·7	6·8	7·4
Breadth	6·6	8·3	9·4
Height	3·4	2·5+	3·1+
Breadth index	115·8	122·1	127

Description.—The first molar is of a rounded quadrangular outline, somewhat broader than long. The three cusps of the trigon are close to each other and joined by a ridge between each pair of cusps. A large hypocone

abuts on the protocone; a ridge joins them. Wear has exposed the dentine of each of the four cusps, as well as of the ridge between the paracone and metacone.

The protocone is a stout cusp in connection with six ridges. It is difficult to decide which of these belong to the protocone and which belong to the three remaining cusps. Two at least are free from doubt. They are at the anterior and posterior extremities of the lingual surface of the cusp. The one in front forms the anterior border of the fissure between the internal cingulum and the protocone and hypocone, but the hinder one divides the same fissure into two subequal parts. Passing clockwise from the antero-internal ridge, we come to what appears to be a double antero-external ridge. This is made up of two independent structures. One of them, the anterior, belongs to the protocone. This is definitely proved by an extension of the dentine lake where the enamel on the crest of the ridge has been worn away. The other, posterior one belongs to the paracone, though in this case the indication is not so distinct. Continuing in the same direction, the next ridge is that which connects the protocone and metacone. Here, owing to the shapes of the respective lakes of dentine, there is no doubt that the ridge is made up of two parts, one to each cusp. The sixth, and last, of these ridges is that joining the protocone and hypocone. This is an offshoot of the latter, since there is a corresponding embayment of the dentine of the hypocone only, and not of the protocone. Hence, we may conclude that the protocone is provided with four ridges, which are antero-internal, antero-external, postero-external, and postero-internal in position.

The paracone has lost some of the enamel on its antero-external surface. Allowing for this, the cusp is seen to be a low rounded cone only less stout than the protocone. It has two ridges, one antero-internal and one postero-median. The latter connects it with the metacone.

The metacone is of approximately the same size as the paracone. It has the same characters, and only differs from that cusp in the two ridges, which are antero-median and internal in position.

The hypocone is almost equal to the two previous ones in size and stoutness, but it has, in addition to the antero-median ridge already mentioned, a faint medio-external ridge in the fovea posterior.

There are at least traces of a cingulum on all four sides of the tooth. That on the lingual side is a massive, fully-developed, basal ridge, almost wide enough to be termed a shelf. It begins at the antero-internal ridge of the protocone, dies out when it reaches the hypocone, and has the summit strongly beaded. From its internal surface, just in front of the postero-internal ridge of the protocone, a spur passes inwards to meet the protocone. The anterior cingulum is, naturally, a more delicate structure. It begins at the antero-internal ridge of the protocone, passes across the front of the tooth, and ends in the centre of the anterior face of the paracone. Any beading of the summit has been destroyed by wear. To say that the anterior cingulum begins at

the antero-internal ridge of the protocone is a matter of convenience, for it is absolutely continuous with the internal cingulum. The external cingulum is a minute ridge joining the bases of the paracone and metacone; it resembles the posterior cingulum in its isolation from its neighbours. The latter joins the metacone and hypocone, and dies away on their posterior faces.

Since the cingulum closes all the gaps between the cusps, it follows that there are four foveae. Ridges from the cusps affect these in varying degree. The fovea exterior is a minute dimple between the paracone and metacone: it has no unusual features. The fovea interior is a large irregularly triangular hollow, or fissure, interrupted by two ridges, one from the cingulum and one from the protocone. These divide it into three parts. The anterior and posterior are deep pits of nearly the same size, whereas the median section is a very small cleft between the two ridges. Similarly, the fovea anterior is divided into two deep, but narrow, fissures by the antero-external ridge of the protocone, which passes downwards and outwards from the summit of the cusp to merge in the anterior cingulum.

The second molar agrees with the first in all essential features, so that only the differences need consideration. Some of these, such as the very definite simple wrinkling of the enamel on the lingual surface of the protocone, doubtless have their origin in the fact that the tooth is less worn than its fellow. Others, which are structural, concern the ridges and cingulum.

The postero-internal ridge of the protocone is absent, and the antero-internal much reduced. The external cingulum and the ridge passing in from the internal cingulum to the protocone are both missing. Hence there is no fovea exterior and the fovea interior is simple and undivided. This tooth has three roots, one internal and two external. The arch of the external roots is wide but pointed above. The internal root measures 5 mm. antero-posteriorly and about 7·5 mm. from above downwards. It has a shallow vertical groove on the lingual surface.

The last upper deciduous premolar is nearly square. Whereas the buccal and anterior margins are straight, the lingual and posterior margins are curved. The interior, lingual, and posterior cingula are strong; the buccal cingulum is obsolete. The buccal cusps are sharp and pointed: the lingual blunter and more depressed. As in the adult, ridges connect all three cusps of the trigon.

Four ridges pass down from the summit of the protocone. The first forms part of the ridge connecting with the hypocone; the second of that connecting with the metacone; the third passes down into the trigon basin; the fourth joins a long ridge from the paracone, and proceeds past it to merge into the anterior cingulum. The enamel on the surface of the protocone is strongly wrinkled.

The hypocone is in contact with a bifurcating ridge from the metacone. From it one ridge passes in to join the ridge connecting protocone and metacone, and one to join a ridge from the protocone.

The metacone, which is relatively high and pointed, has strong anterior and posterior ridges in addition to those mentioned in connection with the hypocone. Hence it has four ridges in all. Three are simple and one is bifurcate.

The paracone is about the same size as the metacone. It has a strong posterior and a weak anterior ridge. The longest and strongest of the three ridges is that which joins the paracone to the protocone.

The external cingulum is a rounded swollen ridge; it is only slight. The remaining cingula are sharp and somewhat crenulated at the summit. The anterior, posterior, and internal foveae are well marked, though the anterior is only a deep cleft.

The symphysis is assigned to this species on account of its size. It is too big and massive for *Limnopithecus*, but yet not big enough for *Proconsul*. A worn left anterior premolar is retained with part of the tooth behind it. In front the crowns of the left canine and incisors have been broken off. Part of the alveolus of the right central incisor remains; the rest of the jaw is lost.

An extended surface of occlusion with the upper canine passes from the summit of the one-cusped premolar down on to the anterior root; any enamel there may have been on the root had long since disappeared, and the surface of the root been worn flat before the animal died. This leaves no doubt that the symphysis is that of a fully grown adult. The incisor roots have the bucco-lingual diameter longer than the transverse. The canine root (7×5 mm.) is relatively small, but there is nothing to show the nature of the crown.

In cross-section the symphysis is stouter than any of those figured by Woodward (1914, fig. 1), and very much stouter than that of *Dryopithecus pilgrimi* (Gregory & Hellman, 1926, fig. 16). The fossa for the insertion of the geniohyoid and geniohyoglossus muscles has two very deep pits at its base. The digastric fossa is not so definite as in *Dryopithecus*, and, to judge from the scar which shows where it was broken off during preparation, the digastric tubercle was small. The inferior margin was not produced backwards to form a simian shelf.

Discussion.—This curious form, at once primitive and specialised in its characters, is included among the Simiidae largely as the result of a process of elimination.

The upper molars of the Cercopithecidae have four cusps arranged in two pairs, so that the crown is divided into two nearly equal parts. Each tooth usually bears high transverse ridges joining its cusps, and the teeth have a strong tendency to bilophodonty. These features also characterise the fossil forms. Even what is perhaps the oldest of them, *Mesopithecus pentelici* from the Europian Pontian, has this bilophodont character well marked. *Oreopithecus* agrees in this respect, although owing to its curious ridges it is often placed in a separate family, the Oreopithecidae. *Xenopithecus* differs, since the cusps are not paired, nor are the teeth bilophodont. Hence it is not one of the Cercopithecidae.

If *Oreopithecus* be regarded as belonging to a separate family, that family cannot include the present genus. In *Xenopithecus* protocone and hypocone are joined by a ridge ; whereas in *Oreopithecus* they are not so joined, but a ridge from the hypocone passes forwards and outwards to join the crista obliqua. This difference in structure is of great importance.

The Gibbons and *Xenopithecus* agree in having a single internal root to the upper molars, though this root is larger in the fossil, but they differ in the size of the hypocone. This is not much more than a rudiment in the Gibbons, whereas in the fossil it is very large.

It is obvious that *Xenopithecus* is not one of the Hominidae, but it may well be included among the Simiidae. The strong paracone-metacone and protocone-hypocone ridges are unusual, but they are developed to some extent among certain members of the group. The cingulum may be matched in *Proconsul* and the trigon in *Dryopithecus* and some Chimpanzees. Even the paracone and metacone are connected in *Dryopithecus darwinii*. Thus Glaessner says, 'Zwischen Para- und Metacon findet sich ein verhältnismässig kräftige Randleiste' (1931, p. 18) ; whilst Remane (1921 *b*, p. 158) says of *D. rhenanus*, 'Der Hypoconus ist durch Randleisten mit dem Protoconus ziemlich eng verbunden.' If the cingula of *Xenopithecus* were suppressed, the ridges which join the cusps would become 'Randleisten.' Thus, the various features occur singly among other species of this group.

Probably *Xenopithecus* is an aberrant form of Anthropoid adapted for a different mode of life, in much the same way that *Alouatta* differs from the rest of the Cebidae through having teeth adapted for its diet of leaves rather than fruit.

Genus *Proconsul* Hopwood.

1933. Ann. & Mag. Nat. Hist. (10) xi, p. 98.

Diagnosis.—Simiidae approximating to the Chimpanzee in size. Premolars bicuspid ; protocone from 130 to 160 per cent the height of the deuterocone ; posterior cingulum well marked. First and second molars quadrate ; trigon very distinct ; proto- para-, and meta-cones of about the same size ; hypocone equal to the protocone, or slightly larger. Third molar reduced, subcircular ; protocone larger than paracone ; metacone and hypocone very much reduced. Internal cingulum of molar teeth strong, external cingulum weak. Enamel wrinkles increase in strength from the first to the third molar.

Lower molars showing the *Dryopithecus* pattern. Hypoconulid central in first and second, buccal in third molars. Third molar with definite anterior transverse crest and strong cingula.

Genotype.—*Proconsul africanus* Hopwood.

Proconsul africanus Hopwood. (Pl. 6. figs. 5–10.)

1933. Ann. & Mag. Nat. Hist. (10) xi, p. 98.

Diagnosis.—As for the genus.

Holotype.—A left maxilla with C–M3 slightly worn. Regd. M 14084.

Material.—In addition to the holotype, a broken mandible lacking the incisors and canines, the whole of the left third molar, and the posterior part of the right, regd. M 14086; a right first upper molar, regd. M 14085; an almost unworn, but weathered crown of a third right lower molar, regd. M 14087.

Dimensions.—

Tooth dimension.		*Proconsul africanus.* Holotype.	*Proconsul africanus.*	Chimpanzee. Regd. 83.1.28.17. B.M. Zool. Dept.	Chimpanzee. Regd. 64.12.1.7. B.M. Zool. Dept.	*Dryopithecus punjabicus.* (From Pilgrim, 1915.)
Upper Dentition.						
C:	Length	11·3	..	11·6	10·9	..
	Breadth	9·1	..	8·6	8·6	..
	Height (bucc.)	15	..	14·6	14·3	..
	Height (ling.)	13·5	..	13·4	14·5	..
	Index	81	..	74	94	..
P3:	Length	7·3	..	7·5	8·3	7·0
	Breadth	9·4	..	8·0	9·9	9·5
	Height (bucc.)	8·1	..	6·6	6·4	6·2
	Height (ling.)	5·0	..	4·9	5·1	
	Index	129	..	107	120	135·7
P4:	Length	5·8	..	6·5	7·2	6·6
	Breadth	8·9	..	9·6	10·5	9·7
	Height (bucc.)	6·4	..	5·5	6·3	5·5
	Height (ling.)	4·8	..	5·2	5·2	
	Index	152	..	148	146	146·9
M1:	Length	7·9	7·8	9·4	10·3	10·4
	Breadth	9·6	9·0	10·6	11·2	11·3
	Height (bucc.)	5·2	4·8	5·2	5·9	5·3
	Height (ling.)	4·3	4·2	5·2	5·3	
	Index	122	115	113	109	108·6
M2:	Length	9·2	..	8·8	10	10·6
	Breadth	11·3	..	10·3	11·6	11·4
	Height (bucc.)	5·4	..	5·1	5·3	5·6
	Height (ling.)	4·5	..	5·1	4·9	
	Index	123	..	117	116	107·5
M3:	Length	7·8	..	8·4	10·3	..
	Breadth	10·2	..	9·8	10·9	..
	Height (bucc.)	4·9	..	3·9	4·7	..
	Height (ling.)	4·4	..	5·1	5·5	..
	Index	130	..	116	112	..

DIMENSIONS (*cont.*).—

Tooth dimension.		*Proconsul africanus.* Left ramus of mandible.	*Proconsul africanus.* Right ramus of mandible.	*Proconsul africanus.* Isolated M3.	Chimpanzee. Regd. 20.4.13.2. B.M. Zool. Dept.	*Dryopithecus punjabicus.* (From Pilgrim, 1915.)
Lower Dentition.						
C:	Length	8·9 (root)	8·9 (root)	..	11·6	..
	Breadth	13·7 (root)	13·2 (root)	..	10·0	..
	Index	154 (est).	148 (est.)	..	86·2	..
P3:	Length	12·5	12·6	..	8·5	..
	Breadth	7·1	7·4	..	8·8	..
	Index	56·8	58·8	..	103·5	..
P4:	Length	7·4 (est.)	7·3	..	8·3	..
	Breadth	8·9 (est.)	8·9 (est.)	..	8·6	..
	Index	120 (est.)	122 (est.)	..	103·6	..
M1:	Length	9·5	9·5 (est.)	..	11·1	..
	Breadth	9·4	9·5 (est.)	..	9·8	..
	Index	99	100 (est.)	..	88·3	..
M2:	Length	11 (est.)	11·7	..	11·1	11·6
	Breadth	10·8	10·8	..	10·1	9·9
	Index	91	92	..	91	85
M3:	Length	11·6 (root)	..	11·9	10·8	12·5
	Breadth	8·9 (root)	10·2 (est.)	9·4	10·1	10·4
	Index	77 (est.)	..	79	94	83

Additional measurements :—

External depth of mandible between P3 and P4	36
External depth of mandible at M3	31·4
Length of symphysis	28·5
Distance of mental foramen from alveolar border	17·5
Maximum diameter of mental foramen	4·3
Minimum diameter of mental foramen	3·0
Length of left inferior series P3 to M3	53

The following measurements were taken in a straight line from the crown of the arch between the two roots to the tips of the roots themselves. No account is taken of the curvature of the roots :—

	C.	P3.	P4.	M1.	M2.	M3.
Anterior root........	17	17	15	10	12	10
Posterior root	..	16	13	13	14	15
Shape of arch	..	Cleft.	Cleft, but wider than P3.	Rounded.	Point.	Point.
Direction of roots....	Vertical.	Vertical.	Vertical.	←—Down and back.—→		
Separation of roots ..	..	Well sep.	←——Pronounced.——→			

Description.—The upper and lower dentitions are described separately.

Upper Dentition.

The holotype has undergone post-mortem deformation, which has caused the tooth-row to bend inwards. The tip of the canine has been displaced downwards and inwards. A fracture passing through the alveolus of P4 has changed the relative positions of the two pieces, and P4 itself has moved out into the wide crack to a position internal to that which it should properly occupy. Apart from these accidents after death, the palate is straight-sided.

The incisor-teeth are missing, only oblique sections of the roots remain. Between the roots the bony alveolar plates are about 2·9 mm. thick, from which it is deduced that the crowns were fairly large and square. A gap of 4 mm. separates the lateral incisor from the canine.

The canine is a stout pointed tooth with a strong cingulum on the lingual surface. For descriptive purposes it may be regarded as a rough four-sided pyramid, which has two lingual and two buccal faces. The proximo-buccal surface is a scalene triangle, slightly convex transversely. It passes into the disto-buccal face through an increase in the convexity of its surface. The latter face is of similar nature, but narrower. Both the lingual surfaces are more complex than the buccal. The proximo-lingual is triangular; it is concave from tip to neck, the concavity is most marked at the neck, and convex transversely; it is the most extensive of the four faces. The disto-lingual face is more correctly a distal face which has a slightly lingual position. It is very narrow and curved lingually. At the base there is a deep groove, which becomes shallower as it passes towards the summit and dies out after covering about two-thirds the height of the tooth.

The third premolar is of the biscupid type usually occurring in anthropoid apes; it has a high sharp-pointed protocone, a lower and blunter deuterocone, and a distinct posterior cingulum. The protocone is roughly pentagonal in cross-section. There is an anterior and a posterior ridge, or keel, on the lingual surface. There are also antero-internal and median ridges which pass down towards the deuterocone, with which the former connects, and divide the surface into three unequal parts. A division of the buccal surface into two faces, of which the antero-external is slightly the smaller, is effected by a strong submedian convexity.

The deuterocone is little more than half the height of the protocone and bluntly rounded; its real shape is obscured by a posterior facet due to wear. A slight ridge on the buccal surface connects with the antero-internal ridge of the protocone.

A well-defined posterior cingulum connects the posterior keel of the protocone with the postero-lingual surface of the deuterocone. The portion nearest the protocone, about one-third of the whole, is unworn and slightly roughened. The remainder is worn smooth by use; its maximum width, 1 mm., is at the floor of the valley between the two cones. The buccal termination is somewhat stout and rounded so as to form an incipient style.

The fourth premolar is a smaller tooth than the former, from which it differs in that the protocone is not so tall and pointed, and also in that it has both anterior and posterior cingula. The protocone has a strong keel in front and behind, as well as an antero-lingual ridge which forms a connection with the anterior keel of the deuterocone. There are three subdivisions of the buccal surface of the protocone ; a strong central convex rib is flanked on either side by much smaller, almost plane areas bounded by the cingulum and the central rib, and which mainly consist of the keel. The lingual surface shows a similar division, which is rendered more distinct by the antero- and postero-lingual ridges. The latter is almost obsolete.

There is a tendency for the deuterocone to form anterior and posterior keels after the manner of the protocone. The anterior keel sends down a ridge from its junction with the cingulum to connect with the antero-lingual ridge of the protocone. Compared with the third premolar, the deuterocone is much smaller in proportion to the protocone ; if the height of the protocone be taken as 100 in each tooth, then the height of the deuterocone in the fourth premolar is 75, compared with not quite 62 in the third.

The anterior cingulum is not so strong as the posterior, and is practically confined to the protocone ; at its buccal end it forms a style as strong as that formed by the posterior cingulum. The latter begins at the posterior keel of the protocone and passes inwards to a point just short of the centre of the lingual face of the deuterocone. Where it forms the boundary of the posterior fossa of the occlusal surface it is worn smooth ; elsewhere it is slightly beaded.

The first molar is somewhat rhomboidal in outline. Owing to the backward extension and large size of the hypocone, the lingual side is longer than the buccal. The crown of the tooth is surrounded by a beaded cingulum, which is discontinuous at each of the angles except the antero-internal. The primary trigon is very distinct with strong ridges joining the protocone to the paracone and metacone, and a deep fissure between the two last. The cusps are low and practically of equal height ; the height of the lingual surface is 83 per cent. of that of the buccal. Both paracone and metacone have anterior and posterior keels, but the posterior keel of the metacone is nearly obsolete. The enamel is smooth and almost devoid of wrinkles, the only ones being where the ridges join the cusps.

The isolated first upper molar agrees with that just described in every essential, even though it differs in points of detail. For example, the valley between the hypocone and protocone is wider than in the holotype, and the ridges on the cusps are somewhat stronger and better defined. Probably the most striking difference is to be found in the cingulum, which is discontinuous only at the antero- and postero-buccal corners for a short distance. It is very much stronger and more distinctly beaded in this tooth than it is in the holotype.

The second molar tooth is larger, stouter, and more wrinkled than the first, which it resembles in its outline and general structure. Owing to the posterior

extension and large size of the hypocone, the tooth has a rhomboidal outline. The trigon is distinct, but the ridges joining the protocone to the paracone and metacone are not so strong as in the first molar, and that between the protocone and metacone is divided by a definite cleft. All four cusps are of approximately the same height. Owing to the fact that there is practically no difference in height between the internal and external cingula, there is only a slight difference in height between the buccal and lingual surfaces. There are anterior and posterior keels to both paracone and metacone, and this tooth differs from the first molar in that the posterior keel of the metacone is more distinct than it is in that tooth. Both the cingula are more distinct than they are in the first molar; the beading is more sharply defined. The internal cingulum is carried round the back of the tooth to terminate on the posterior face of the hypocone, so that, except for two small gaps (one posterior and one antero-external), the cingulum encircles the tooth.

The wrinkling of the enamel is very distinct. On the buccal surface of the hypocone are three wide, deep, slightly sinuous grooves, whereas on the corresponding surface of the protocone there are only two grooves of the same simple unbranched type. Passing inwards from the anterior surface of the protocone, to the lingual and thence to the posterior surface, there are nine small but clear indentations of the enamel at the base of the cone.

The third molar is much reduced, subcircular, and almost bicuspid from the diminution in size of the metacone and hypocone. The protocone and paracone are as large as in the second molar, but more depressed. They are joined by a ridge which is bent anteriorly, and which forms a slight node where it joins the anterior cingulum. The enamel of these two cusps is wrinkled; that of the protocone has furrows on the buccal surface and pits round the base of the lingual surface, whereas the paracone is wrinkled on the lingual surface. None of the wrinkling is as regular as in the second molar.

Although the metacone is small and mis-shapen it is a distinct cusp, but the hypocone, which is almost worn away, is little more than a superficial feature in the enamel of a broad shelf-like cingulum. The cingulum appears to be continuous all round the tooth; it is beaded, and on the lingual side the beading is coarser than in either the first or second molars.

Lower Dentition.

The lower dentition of this species is not so well known as the upper because the teeth are either broken off level with the mandible, incisors, and canines, or else so worn that the interpretation of their structure becomes a matter of extreme difficulty and doubt. Only the third premolar and an isolated third molar can be described in detail.

The roots of the two median and right lateral incisors are preserved in the right mandibular fragment. Each tooth is produced in a bucco-lingual direction, compressed transversely, and has a single wide shallow groove on the interstitial surfaces. The lateral root is larger and stouter than the median, and

in this root alone there is a satisfactory section of the pulp-cavity, which shows as an elongate narrow canal, about 2 mm. long in a bucco-lingual direction and 0·5 mm. in its greatest width. It is nearer the buccal surface, and is rounded at that end, whereas its lingual end appears to be pointed.

The canine-root is separated from that of the lateral incisor by a gap of from 2 to 3 millimetres. It is inserted obliquely across the mandible, is a rounded oblong in cross-section, and has an oval pulp-cavity which is 3 mm. long and 1 mm. wide. The antero-internal and postero-external angles are more rounded than the other two, which are almost right angles. The interstitial surfaces are almost flat, only the proximal having a slight indication of the groove seen on the incisor-roots.

The anterior premolar (P3) is a large, subcaniniform, twin-rooted tooth, set obliquely in the jaw. It consists of a single massive cone, with a basin-shaped heel and a slight antero-internal cingulum. The tooth itself presents four faces for description, namely, two anterior and two posterior. Of these the antero-external is possibly a more or less arbitrary selection, for it consists of the occlusal surface where this tooth is worn against the upper canine.

The antero-external or occlusal face is 10·6 mm. long and 2 mm. wide. It extends from the apex of the tooth down the whole extent of the enamel, which is produced down on to the anterior root. Passing downwards and forwards it soon changes direction to pass downwards and outwards. The postero-external face is an irregular triangle which is gently convex from above downwards, and rather more convex from side to side. Between them these two faces form the buccal surface of the tooth.

The antero-internal face consists of two parts—a larger anterior portion which is concave from above downwards as well as from side to side and a smaller posterior portion which is convex in both directions. This face is separated from the postero-internal one by a very sharp angle due to a change of direction through which the latter is almost wholly posterior in position. Both this angle and that separating the postero-internal and postero-external faces are worn by occlusion with the upper dentition. The postero-internal face is triangular and concave, the concavity passing downwards into the basined talonid.

There is an almost obsolete internal cingulum, and the convex posterior portion of the antero-internal face has something of a flattened buttress, the metaconid, closely pressed against the lingual surface of the tooth. All this is indefinite, but the talonid is well marked and, by combining the observations made on either tooth, it is seen to have incipient buccal and lingual cusps which show as minute lakes of dentine.

The fourth lower premolar is so worn and damaged that certain features have been wholly destroyed; chief of these are all those dependent on the enamel of the lingual surface, which has entirely disappeared. The tooth itself is bicuspid with a large basined heel on which stand two cusps. Apparently there was a small fovea anterior.

Both first lower molars are so damaged that it is impossible to say whether they had a hypoconulid or not, although analogy with the second molars, as with the isolated third molar, makes it probable that they had. The dentine lakes are transverse and, in the left tooth, not yet confluent throughout their length, whence one deduces more or less of a division into anterior and posterior ridges, the protolophid and metalophid. The tooth is wider behind (9·5 mm.) than in front (8·5 mm.). No signs of a cingulum remain.

The right second molar has received no damage other than that due to wear; hence the position and number of the cusps is not in doubt. This tooth shows the typical *Dryopithecus* pattern of five cusps with the metaconid and hypoconid in contact. The hypoconulid is noteworthy for its position in the centre of the posterior end of the tooth. Owing to wear, each cusp has a central lake of dentine; of these, the hypoconid is the largest and is confluent with that of the hypoconulid, the next largest. Then follow in order the lakes of the protoconid, entoconid, and metaconid respectively. This proves that the greatest amount of wear came on the postero-external part of the crown. There is no definite cingulum preserved, although the general appearance of the tooth conveys the impression that there may have been a partial cingulum on the labial side at least, and possibly on the lingual side as well. This impression is strengthened on examination of the isolated lower third molar.

The third lower molar is known from an isolated crown of an almost unworn, though somewhat weathered, tooth from the right side. Its outstanding features are the arrangement of the three external and two internal cusps in two parallel rows, the large size of the fovea anterior and fovea posterior, the relatively strong ridge connecting the two anterior cusps, and the marked cingula. All the cusps are low and obtuse.

The protoconid has four strong crests—an anterior, a posterior, a medio-buccal, and a medio-lingual. These give the cusp a pyramidal appearance. The metaconid has only one ridge, medio-buccal in position, which joins the corresponding ridge of the protoconid and the two form a low, but distinct protolophid. The hypoconid is so damaged through weathering that it is not safe to make any detailed statements concerning its construction. It appears to have five crests—one anterior, one posterior, one buccal, and two lingual. Of these the anterior and posterior seem to be shorter than the other three. Damage, too, has obscured the characters of the hypoconulid, which is in the same line as the protoconid and hypoconid. So far as can be seen, it is much smaller than the three previous cusps, and has the enamel heavily wrinkled. A crest on the lingual surface passes forwards and inwards to join one from the entoconid. This last cusp is of about the same size as the hypoconulid, but more slender, pointed, and better defined. Its posterior face is deeply concave, and a postero-buccal crest passes downwards and backwards to meet that coming from the hypoconulid.

The anterior cingulum is very strong. It forms the anterior wall of the deep fovea anterior, of which the posterior wall is formed by the ridge connecting

the protoconid to the metaconid. It has the beaded character seen in the upper molars, and the whole of the enamel lining the fovea anterior is wrinkled by simple, straight, unbranched furrows, which pass down to the deep transverse cleft at the bottom. The anterior ridge of the protocone interrupts the cingulum, but the space between that ridge and the medio-buccal ridge is occupied by an almost equally strong cingulum similarly beaded. After this latter interruption the cingulum appears to continue right along the buccal and posterior margins of the tooth, and to follow along the lingual margin to the posterior surface of the entoconid, where it finally ceases. That part of it which bounds the fovea posterior shows the same kind of wrinkling of the enamel as that seen in the fovea anterior.

Most of the wrinkles in the enamel occur in the foveae at either end of the tooth, and are described above, but there are others which pass down into the central basin of the crown. One comes down from the protoconid; one is between the protoconid and the hypoconid; three are between the entoconid and metaconid; and two are on the posterior face of the protolophid. An additional wrinkle between the hypoconid and hypoconulid is the longest. This is complicated by the presence of four tributary wrinkles which pass into it from the hypoconulid and the crista obliqua, which connects that cusp to the entoconid.

The tooth just described is broken off at the roots. There were two of these, an anterior and a posterior. The former expanded transversely. It supported the two anterior cusps. The latter, which was massive, supported the remainder of the crown. A similar arrangement is seen in the corresponding tooth of the left mandibular ramus which is broken away, leaving the roots still in the jaw.

The third molar of the right ramus is broken across obliquely, so that the anterior cusps alone remain. All the jaw behind the fracture has been lost, nor could it be found after the most careful search. That portion of the tooth which remains is very worn, and adds nothing to the description already given. All the wrinkles are obliterated, the anterior fovea has disappeared, and the dentine of the protoconid is exposed in a large depression.

The inner surface of the left mandibular ramus was dissected away so as to expose the roots of the premolar and molar teeth, as well as the posterior surface of the canine-root. This last is single, very stout, and vertical or nearly so. In its position it differs from all the anthropoids quoted by Gregory and Hellman (1926, Table xlii), but agrees with the human canine. The roots of the third premolar are directed downwards and very slightly forwards. They are both very thick, but the posterior root is thicker, shorter, and situated more to the lingual surface of the jaw than the anterior root. In contrast to the third premolar, the fourth has the most slender roots of all the cheek-teeth. They are quite straight, and are 4·5 mm. apart at their tips. All the molars have the roots more or less curved backwards. In the first and third

molars the posterior root is larger and straighter than the anterior, but in the second molar the anterior root is the larger.

Owing to heavy impregnation with mineral matter the specimens are almost opaque to X-rays; nevertheless, working with a Coolidge Universal Tube at 30 inches, with a current of 30 milliamps at a pressure of 90 kilo-volts, satisfactory images of the dissected left ramus were obtained with an exposure of 10 seconds.

The photographs show the nerve-canals in the posterior roots of the third and fourth premolars to have a maximum diameter of 0·6 and 0·8 mm. respectively; their junction with the pulp-cavity is not shown. The pulp-cavity of the left first molar is visible only in the posterior root-shadow and the hinder half of the crown. The canal in the root is of approximately the same diameter as the height of the cavity in the centre of the crown, but the cavity increases in size at its junction with the canal from the root, and at this point the width of the shadow is just over half a millimetre. In no other crown is the pulp-cavity visible.

Osteology.

Owing to post-mortem deformation the maxillary fragment is confusing in its osteological characters. Seen from in front, or in profile, the chief feature is the pronounced slope of the subnasal area, indicating a notable degree of prognathism. Another prominent feature in the anterior region is the manner in which the canine and anterior premolar are inserted into the jaw. They carry on the slope of the facial surface, and project at an angle of approximately 45° to the vertical. The root of the zygomatic process of the maxilla has its origin very close to the alveolar border, and extends forward to come into line with the anterior margin of the first molar. Seen from below, the most prominent feature is the very shallow dome of the palate.

Despite its broken condition, the mandible affords valuable information as to its characters. It is very massive and deep, with a long symphysis which does not retreat as much as in the Chimpanzee. The outer surface below the premolars and first molar bears a wide but shallow depression, due, in part, to the everted inferior border of the bone. The mental foramen is single and situated under the anterior root of the third premolar. On the inner surface a low rounded ridge continues the line of the symphysis backwards and upwards along the jaw towards the ascending ramus. Between this ridge and the alveolar border the bone is hollowed out in a shallow depression. At the level of the first molar the ridge seems to bifurcate, sending an indistinct branch towards the angle of the jaw. The area in the fork is also excavated. One very important character is the almost plane surface of the inner aspect of the jaw below the third molar.

Comparisons.—As these remains were found in Africa, the obvious comparisons are with the Gorilla and Chimpanzee. Similarly, the Miocene age of the beds in which they were found suggests a comparison with the

Eurasiatic 'genus' *Dryopithecus*. It is also evident from the foregoing description that comparisons with the Orang Utan and *Palaeosimia* are more or less academic, since the relationship is remote.

Comparisons with *Dryopithecus* are complicated by the rarity of specimens of the upper dentition of that genus and by the worn state of the lower dentition of this species. Gregory (1922) records six species of *Dryopithecus*, viz., *D. chinjiensis* Pilgr., *D. punjabicus* Pilgr., *D. giganteus* Pilgr., *D. fontani* Lartet, *D. rhenanus* (Pohlig.), and *D. darwini* Abel. Of these six, two only, *D. punjabicus* and *D. rhenanus*, are represented by upper teeth ; the first by a maxilla with the premolars and first and second molars, and the second by two isolated molars. Our knowledge of the remainder is limited to the lower dentition, and in some cases to single teeth. The three species described by Brown, Gregory, and Hellman (1924) are also founded on portions of lower jaws. From this it follows that the remains of *Proconsul africanus*, unsatisfactory though they be in certain respects, are at present unique in affording a relatively complete picture of the upper and lower dentition of a Miocene anthropoid ape.

The outstanding characters of the upper cheek-teeth of this species are :—

(1) The tall, sharp-pointed buccal cusps of the premolars.
(2) The quadrate outline of the molars.
(3) The prominent trigon.
(4) The very strong cingulum.
(5) The prominent hypocone.
(6) The rounded, reduced third molar.

Of these the third and fourth are primitive characters, whereas the remainder are specialised. This indicates a mixture of characters, and closer examination proves that this mixture pervades the entire upper dentition. For example, the premolars are specialised in their high outer cusps which, in the third premolar especially, are so marked as almost to make the teeth caniniform. At the same time their great breadth is to be accounted a primitive character, persisting from very early times when the ancestral anthropoids all had the anterior teeth so crowded that any increase in size had to take place transversely. Similarly, the first and second molars are very primitive in their marked tritubercular pattern and strong cingula, but they are equally specialised in their large hypocones, quadrate contours, and in the greater length of the lingual compared with the buccal surface.

The upper dentition has many resemblances to that of *Dryopithecus*, so far as the latter is known to us, but the differences are no less important. Points of resemblance are :—

(*a*) The two-cusped premolars.
(*b*) The four-cusped molars.
(*c*) The marked trigon.
(*d*) The quadrangular contour.

But the teeth differ from those of *Dryopithecus* in :—

(*a*) Their smaller size.
(*b*) Their strong cingula.
(*c*) Their hypocones, which are much larger than those of either *D. punjabicus* or *D. rhenanus*.
(*d*) The disparity of size between the buccal and lingual cusps of the premolars when compared with the corresponding cusps in *D. punjabicus*.
(*e*) The relatively shorter antero-posterior diameter of the cheek-teeth when compared with *D. punjabicus*; this is not so marked when comparison is made with *D. rhenanus*.

Taken together, these appear to me sufficient to exclude the African fossils from the 'genus' *Dryopithecus*. Even though (*a*) and (*e*) might be regarded as individual or specific characters, the remainder are, in the sum, differences which separate genera rather than species.

The main points in which the teeth of *P. africanus* differ from those of the Gorilla are :—

(*a*) Their smaller size.
(*b*) The greater width and smaller length of the premolars.
(*d*) The greatly reduced M3.
(*e*) The pronounced cingula.
(*f*) The stronger crista transversa anterior and crista obliqua.

In this instance also, these differences, together with others which are not so immediately obvious, have a value which must be accorded generic rank.

It is not so easy to separate the upper dentition of *P. africanus* from that of the Chimpanzee. The teeth of the latter are so extraordinarily variable in their size, shape, and occlusal relationships that it is difficult to know what is the normal dentition. In this connection the general description given by Prof. W. K. Gregory (1922, pp. 343–344) may be quoted in full. He says :— 'The upper molars clearly retain the sharp V-like ridges of the primitive tritubercular pattern, but they add thereto a poorly developed posterior ridge, runnng from the enlarged hypocone to the metacone. There is a decided tendency to divide the internal root into an anterior and posterior moiety, or, rather, the formerly distinct roots may be in course of coalescing . . . . The third upper and lower molars are somewhat reduced in size and degenerate in form . . . . The molar crowns are coarsely wrinkled, the cusps being lower than in the Gorilla. The upper premolars are comparatively small and are prominently bicuspid . . . . The canines form stout tusks.' All this can be applied almost equally well to the fossil teeth under consideration, but there

are characters in the fossil which are not present in the recent species, and *vice versa*. Chief of these characters are :—

(*a*) The anterior premolar is more caniniform in the fossil.
(*b*) The premolars, especially P4, are shorter in the fossil.
(*c*) The fossil molars have a very prominent cingulum.
(*d*) The ridge joining the metacone and hypocone is present in the fossil only in the first molar, and that tooth alone has a definite fovea posterior.
(*e*) The Chimpanzee has the enamel more wrinkled than it is in *P. africanus*.
(*f*) The entire premolar-molar series is cut at about the same time in *Proconsul*, whereas in the Chimpanzee the first molar erupts in the sixth year, and the third not before the fifteenth year (Zuckerman, 1928).

Hence it would seem that the dentition of *Proconsul* is more primitive than that of the Chimpanzee, and for that reason I have placed it in a separate genus.

There is no insuperable difficulty in the way of deriving the recent from the fossil dentition. The main requirements are a slight lengthening of the muzzle with a corresponding increase in the length of the tooth-row, a reduction of the cingulum, and a reduction in size of the buccal cusps of the premolars. The last upper molar of the Chimpanzee has a larger metacone than that of *P. africanus*, but a lengthening of the upper jaw would allow the reduced metacone to increase in size and so give rise to the condition found in the Chimpanzee.

The lower teeth were compared with the same three forms as before, beginning with *Dryopithecus*. Here we are handicapped, not only by lack of material for comparison, but also by the extremely worn and damaged condition of the main material of *P. africanus*. Indeed, if this species were represented only by the lower jaw, to separate it from *Dryopithecus* would be difficult.

The only Miocene ape from Africa with which it can be compared is *Dryopithecus mogharensis* (Fourteau, 1920, p. 95). That species is not well figured, and the exiguous description leaves much to be desired. Remane (1924) has already discussed Fourteau's work. He says, 'Nur bei Würdigung der künstlichen Gattung *Dryopithecus* kann *Dr. mogharensis* in dieser bleiben, in Wirklichkeit bleibt es noch unsicher, ob es um einen Hylobatiden oder Simiiden handelt . . . . '. Pending re-examination of the specimens, the matter may well rest there. At present the Egyptian specimens are of no use in making critical comparisons.

The metaconid of the third premolar of *P. africanus* is indicated by a faint triangular area on the labial surface of the tooth, the antero-posterior sulcus is equally faint. In both these respects it is at least as primitive as *D. pilgrimi*, and more primitive than any other species of *Dryopithecus* in which this tooth is known. The anterior premolar is also narrower than any of the corresponding

teeth of *Dryopithecus* quoted by Gregory and Hellman (1926), and so might be regarded as primitive in that respect also were it not for Remane's demonstration (1921) that the breadth index is not a reliable criterion. Another marked difference lies in the extension of the enamel on to the anterior root of the tooth of *Proconsul*. This is a distinctly simian character not seen in any species of *Dryopithecus*.

The fourth premolar agrees with those of the Indian species of *Dryopithecus* in being broader than long, and so differs from *D. fontani*. The agreement is also with the Indian rather than the European in that the external cingulum is absent or obsolete. In the larger talonid basin and very distinct hypoconid and metaconid, *P. africanus* appears to be more advanced than any species of *Dryopithecus*, with the possible exception of *D. frickae*. The trigonid would be higher than the talonid in the unworn tooth, but probably the relative height would be no greater than it is in *Dryopithecus*.

The first molar is so worn as to render comparisons impossible.

The length, breadth, breadth index, and talonid index (85·5) of the second lower molar are all well within the limits of variation of '*Dryopithecus*'. It agrees with *D. cautleyi* and *D. frickae* in the more central position of the hypoconulid, and differs in this respect from all the other species. This relationship is reversed when the external cingulum between the protoconid and hypoconid is considered. The relatively flat occlusal surface, especially on the buccal side, agrees with *D. frickae*, *cautleyi*, *pilgrimi*, and *punjabicus*. If the isolated third lower molar is a safe guide, the crown must have been lower and flatter than it is in *Dryopithecus*.

The third lower molar differs from all those in the specimens of *Dryopithecus* hitherto described because the buccal margin consists of three cusps (protoconid, hypoconid, and hypoconulid) arranged in a perfectly straight line. The maximum height, too, is very much less than in any known species of *Dryopithecus*. There are other differences also, such as the small size of the hypoconulid and entoconid when compared with the remaining cusps, the very large fovea posterior, and the relatively strong ridge which joins the hypoconulid to the entoconid. The labial margin has well-defined grooves behind the two cusps which cause it to have a serrated appearance resembling that described by Pilgrim in *D. punjabicus*. The cingulum is stronger than any found among the various species of *Dryopithecus*, most of which have lost this feature altogether.

When comparison is made with the Chimpanzee, the disparity between the mandibular rami and the rough general agreement between the cheek-teeth are at once evident. In addition to the more massive mandible, *P. africanus* has the mental foramen under the anterior root of the third premolar, and thus farther forward than in the Chimpanzee, which usually has the foramen under the fourth premolar. On the other hand, the symphysis of the Chimpanzee does not extend any farther backwards than that of *Proconsul*. What value attaches to this observation is not clear, for in all genera of Anthropoid apes the backward extension of the mandible appears to vary within wide limits,

and, so far as I have been able to trace, apart from one paper by Woodward (1914), very little work has been done on that region of the lower jaw.

In its general form and structure, the third lower premolar of *P. africanus* comes within the limits of variation of the corresponding tooth in the Chimpanzee, nor does there appear to be any definite criterion whereby the teeth may be separated. Speaking of the metaconid of the Chimpanzee, Remane (1921, p. 60) says :—' Es finden sich alle Uebergänge von vollstandigem Fehlen bis zu relativ starker Entwicklung.' Examination of the series in the British Museum led to the same conclusion. For what it may be worth, one may point out that the roots in the fossil appear to be stronger than they are in the Chimpanzee.

The fourth premolar and first molar of the Chimpanzee and *Proconsul* are scarcely comparable owing to damage and wear, but if specimens of both in the same state of wear are placed side by side they are practically indistinguishable.

The only feature which can be said to separate the second lower molars of *Proconsul* from equally worn specimens of the Chimpanzee is the central position of the hypoconulid, though according to Gregory and Hellman (1926, Table xliv) the position of this cusp in the Chimpanzee varies from lateral to central (rarely) and hence would afford no distinction.

The isolated third lower molar of *Proconsul* is at once separated from that of the Chimpanzee by its much lower crown, the peculiar arrangement of the buccal cusps, the strong cingula, and the blunt rounded tops of all the cusps. It is also much narrower than any quoted by Remane, or by Gregory and Hellman.

Taking the Gorilla as our standard of comparison, we find that the third lower premolar of *Proconsul* is :

(*a*) Smaller.
(*b*) Narrower ; the index varies from 56·8 to 58·8, whereas the minimum value quoted by Gregory and Hellman (*op. cit.* p. 44) is 66·4 and the average 86·2.
(*c*) Shallower in the talonid basin.
(*d*) Even less developed as regards the metaconid, although the Gorilla itself is backward in this feature.

Similarly, the third molar of *Proconsul* differs from that of the Gorilla in its :

(*a*) Size, which is less.
(*b*) Low depressed cusps.
(*c*) Strongly developed cingula.

But it agrees with the Gorilla, as well as with the Chimpanzee, in having ridges between the protoconid and metaconid, and between entoconid and hypoconulid.

The mandible is much deeper than it is in the Gorilla. If the external depth of the jaw at the front of M3 be expressed as a percentage of the length

of the premolar-molar series, the resultant for *Proconsul* is 60 per cent, for the Gorilla 50 per cent, whereas in two Chimpanzees taken at random it varied between 48 and 58 per cent. On the other hand, the mandible is about as thick as those of the Gorilla and Chimpanzee. The ratio employed by Gregory and Hellman (*op. cit.* Table i) is the thickness of the jaw across the anterior moiety of the third molar expressed as a percentage of the outside depth of the jaw at the same place. They give the value for the Gorilla as 54·76 per cent and for the Chimpanzee 53·85 per cent. The ratio in *Proconsul* is 54·1 per cent.

Discussion.—This paper was nearly finished when Dr. L. S. B. Leakey submitted some remains of anthropoids, both originals and casts, to Sir Arthur Keith, F.R.S. These specimens were obtained from the Lower Miocene of Rusinga Island in the Kavirondo Gulf, about one hundred and sixty miles West of Koru. Sir Arthur generously allowed me to examine them with him, and to make comparisons with my own material. To his courtesy and consideration I am much indebted, and I wish to express my thanks for the privilege thus extended to me.

It had all along been evident that, even allowing for the post-mortem deformation of the maxilla, the upper and lower teeth from Koru could never have been made to occlude, and that the upper teeth represented a smaller animal than the lower. Among Dr. Leakey's material is a cast of a mandibular ramus which occludes perfectly with the holotype of *P. africanus*, whereas his maxillary specimens, which are from larger animals, occlude with the mandible from Koru.

Until the newly discovered material is described and made available it is not permissible to comment on it, though Dr. Leakey is to be congratulated on his good fortune. At present there is no reason for separating the mandible and maxilla described in this paper. Not only has individual variation to be taken into account, but also variation between the sexes. The results of this double variation are familiar to anyone who has studied a long series of anthropoid skulls, and enjoins caution when dealing with a few specimens.

It has been pointed out above that there is a marked general resemblance between *Proconsul* and the Chimpanzee, and that Gregory's description of the latter is almost equally applicable to the former. Indeed, the main difference between the two is the more primitive character of the fossil. In its anterior mandibular premolar, which has the enamel produced down on to the anterior root, *Proconsul* is more simian than *Dryopithecus*, and more specialised than many Chimpanzees. On the other hand, there are no great difficulties in the way of deriving the dentition of the Chimpanzee from that of *Proconsul*, and I regard the latter as ancestral to the Chimpanzee.

This new genus has no close connection with the South African form *Australopithecus*. The first molars of that genus are much more like those of the Gorilla than either the Chimpanzee or *Proconsul*. Indeed, there is very little difference between the Gorilla and *Australopithecus*, which appears to be a precocious offshoot of the gorilline lineage.

III. Africa and the evolution of Anthropoids.

Including those described in this paper, there are seven genera of fossil anthropoids known from Africa. Their localities and horizons are :—

Egypt (Fayûm)	Lower Oligocene	*Propliopithecus.*
Egypt (Maragha)	Burdigalian	*Prohylobates.* '*Dryopithecus.*'
Kenya	Lower Miocene ?	*Limnopithecus.* *Xenopithecus.* *Proconsul.*
Union of South Africa .	Upper Pliocene ?	*Australopithecus.*

Schlosser (1911) pointed out that *Propliopithecus* is structurally the primitive stage from which evolved the dentitions of the later anthropoids and man. This view is supported by Gregory (1916, 1922), who extends it by placing the genus in a central position leading to the Hylobatidae on the one hand and to the Simiidae on the other. Remane (1921), basing his opinion on the reduction of the trigonid, includes *Propliopithecus* among the Hylobatidae and separates it from the Simiidae.

Fourteau (1920) describes *Prohylobates* as a direct ancestor of *Hylobates*, but, as Remane (1924) showed, it is more specialised than, and hence not ancestral to, *Hylobates*. His suggestion that it is a specialised descendant of *Propliopithecus* unconnected with higher forms is, apparently, well founded.

Limnopithecus is not ancestral to *Hylobates* ; it has a more specialised milk-dentition. The permanent teeth differ from those of *Prohylobates* in the presence of a small cingulum, but agree with them in the variation of the breadth index between 90 and 100. This genus, too, is probably a specialised member of the *Propliopithecus* lineage.

Xenopithecus is an unsolved problem : that it is a descendant of one of the Fayûm primates is only a guess incapable of proof until comparable material is found. Either the lower dentition of this genus or the upper dentition of one of the Fayûm genera is needed.

Dryopithecus mogharensis has not yet been discussed, except by Remane (1924), who regards it as indeterminate on the material at present available, but expresses the opinion that it may be another derivative of *Propliopithecus*.

Proconsul is definitely more primitive in its dentition than any fossil member of the Chimpanzee-Gorilla group hitherto described. The lower dentition is not yet known in sufficient detail for a critical opinion to be based on it. The genus is related to *Dryopithecus* and ancestral to the Chimpanzee.

This wealth of fossil anthropoids from the middle Tertiary beds of Central Africa sheds new light on the problem of the dispersal of the higher Primates. Hitherto all such remains have been found in Europe or in Asia ; the theories of their origin and dispersal have alternated between African and Asiatic centres. The present discoveries suggest that the former may eventually prove to be correct, and that the course of events may have been similar to

the outline sketched in the following paragraphs. It should be made quite clear from the outset that this outline is tentative. The total number of fossil specimens of the higher Primates is too small to justify a dogmatic statement about their evolution, and this sketch should be taken for what it is meant to be, namely, a personal interpretation of the known facts, an interpretation which may well be proved false as our knowledge increases.

Propliopithecus, or something closely resembling it, appears to provide a starting-point from which more advanced animals arose. Its descendants, radiating from N.E. Africa or Arabia, entered Europe and Asia, and pressed southwards farther into Africa. Wherever they went, they continued to evolve, some in one direction and some in another, but all of them were restrained by the limitations of their nature. They began as primitive anthropoids, and their evolution was governed by that fact. If they had met with identical conditions in all three directions, their evolution would have been along identical lines; the conditions were not identical, nor was the course of their evolution. Nevertheless, parallel evolution could and did occur—for example, there are three Chimpanzee-like forms, namely, *D. rhenanus* in Europe, *D. punjabicus* in India, and *Proconsul* in Africa.

Those forms which went south gave rise to the modern African anthropoids. Their stock also provided the unprogressive *Limnopithecus*, the aberrant *Xenopithecus*, and the precocious *Australopithecus*, but these branches from the main stem lead nowhere.

The European descendants paralleled the African in their evolution; hence the gorilline features of *Dryopithecus fontani* and the resemblances between the Chimpanzee and *D. rhenanus*. They are of importance; for, from a complex centred round *D. rhenanus* the human line may have had its origin.

The branch which wandered into Asia also paralleled the African Chimpanzee-Gorilla group fairly closely, but there were certain influences at work which prevented this parallelism proceeding as far as in the European species. The effect of these influences is clear. 'On the whole the Indian "*Dryopithecus*" seems to be allied rather with the orang than with the gorilla-chimpanzee-man group, the former constituting an eastern, the latter a western division of the family Simiidae' (Gregory & Hellman, 1926, p. 84).

Despite the probability that the higher primates had their origin in Arabia or North-Eastern Africa, it does not follow that Africa is the continent in which the final transition from ape to man was effected. At present there is practically no evidence in support of such a view, but much can be said for the Central Asian origin of man.

A branch of the *Dryopithecus rhenanus* complex travelling eastwards penetrated to Central Asia after the Himalayan uplift had progressed so far as to constitute a barrier to the northward migration of the Indian genera with their Orang-utan affinities. There further evolution resulted in man, and from thence human beings spread over the face of the earth. In other words, the primary centre of dispersal of the anthropoids was in or near Northern Africa,

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LIMNOPITHECUS, XENOPITHECUS and *PROCONSUL*

and a branch of the western group wandered through Europe to Central Asia, where it gave rise to man.

IV. Acknowledgments.

I have to express my grateful thanks to Professors G. Elliot Smith, F.R.S., and H. A. Harris, M.D., D.Sc., who provided me with the X-ray photographs, as well as to Mr. J. Melville, to whose skill as radiographer I am indebted for the technical excellence of the photographs themselves.

I am no less obliged to E. J. Wayland, Esq., to Dr. Gordon, and E. Cooper, Esq., the former and present owners of Legetet Farm, and to A. S. Kerton, Esq., of Koru, for their manifold help both in East Africa and at home. To them, too, I tender my thanks.

List of Works consulted.

Andrews, C. W. 1914. Quart. Journ. Geol. Soc. lxx, pp. 163–186, pls. xxvii–xxix.

Brown, B., Gregory, W. K., & Hellman, M. 1924. Amer. Mus. Novitates, No. 130.

Fourteau, R. 1920. Contribution à l'Etude des Vertébrés Miocènes de l'Egypte. Survey Department, Cairo.

Glaessner, M. 1931. Ann. naturhist. Mus. Wien, xlvi, pp. 15–27, pl. ii.

Gregory, W. K. 1916. Bull. Amer. Mus. Nat. Hist. xxxv, pp. 239–355, pl. i.

—— 1922. The Origin and Evolution of the Human Dentition, pp. xviii, 548, pls. i–xv. 8vo. Baltimore.

—— & Hellman, M. 1926. Amer. Mus. Nat. Hist., Anthrop. Papers, xxviii, pt. 1.

Hoffman, A. 1893. Abhand. k.-k. geol. Reichs. xv, Heft 6.

Hopwood, A. Tindell. 1933. Ann. & Mag. Nat. Hist. (10), xi, pp. 96–98.

Mayet, L., & Lecointre, Ctsse P. 1909. Étude Sommaire des Mammifères Fossils de la Touraine. Ann. Univ. Lyon, n.s. Fasc. 26.

Pilgrim, G. E. 1915. Rec. Geol. Surv. India, xlv, pp. 1–74, pls. i–iv.

—— 1932. The Fossil Carnivora of India. Palaeont. Indica, n.s. xviii.

Remane, A. 1921 *a*. Centralbl. Min. Geol. Paläont. Jahrg. 1921, pp. 335–339.

—— 1921 *b*. Arch. Naturgos. lxxxvii, Abt. A, Heft 11, pp. 1–179.

—— 1924. Centralbl. Min. Geol. Paläont. Jahrg. 1924, pp. 220–223.

Schlosser, M. 1911. Beitr. Paläont. Geol. Oest.-Ung. xxiv, pp. 51–167, pls. ix–xvi.

—— 1923. *See* Zittel, K. A. von.

Weber, M. 1904. Die Säugetiere, pp. xii, 866, 8vo. Jena.

Woodward, A. S. 1914. Quart. Journ. Geol. Soc. lxx, pp. 316–320, pl. xliv.

Zittel, K. A. von. 1923. Grundzüge der Paläontologie, ii, pp. v, 706, ed. 4. 8vo. Munchen. (Mammals revised by Max Schlosser.)

EXPLANATION OF PLATE 6.

Fig. 1. *Limnopithecus legetet* Hopw. First and second right lower molars; occlusal aspect, × 2. *Holotype*, regd. M 14079.

Fig. 2. *L. legetet* Hopw. Part of the left mandibular ramus with deciduous dentition; occlusal aspect, × 2. *Paratype*, regd. M 14080.

Fig. 3. *Xenopithecus koruensis* Hopw. First and second left upper molars; occlusal aspect, × 2. *Holotype*, regd. M 14081.

Fig. 4. *X. koruensis* Hopw. Posterior right upper deciduous molar; occlusal aspect, × 2. *Paratype*, regd. M 14082.

Fig. 5. ***Proconsul africanus*** **Hopw.** Left maxilla; occlusal aspect, × 1. ***Holotype***, regd. M 14084.

Fig. 6. The same; labial aspect, × 1.

Fig. 7. *P. africanus* Hopw. Right mandibular ramus; internal aspect, × 1. Regd. M 14086.

Fig. 8. *P. africanus* Hopw. Left mandibular ramus; internal aspect dissected to display the roots of the teeth, × 1. Regd. M 14086.

Fig. 9. *P. africanus* Hopw. First right upper molar; occlusal aspect, × 2. Regd. M 14085.

Fig. 10. *P. africanus* Hopw. Third right lower molar; occlusal aspect, × 2. Regd. M 14087.

[The register-numbers are those of the Department of Geology of the British Museum (Natural History). Figures 1, 2, 4 were drawn by Miss Barbara Hopkins.]

Studies in the Phytoplankton of the Lowland Waters of Great Britain.— No. VI. The Rotifer Fauna associated with the Phytoplankton of twenty-eight Lowland Waters. By B. MILLARD GRIFFITHS, D.Sc., and F. E. COCKS.

[Read 26 October 1933]

THE alga flora of the plankton of the smaller bodies of still water in the lowlands of Great Britain is frequently much less in bulk than the fauna, and the latter usually consists largely of Rotifers. In the smaller pools, the summer plankton may consist almost entirely of Rotifers, but in the larger pools and lakes the rotifer constituent of the plankton tends to diminish both absolutely and relatively.

In the following account a record is given of the rotifer fauna of the plankton of the open water of seventeen Northumbrian, eight Worcestershire, and three Berkshire pools. The collections were made by Dr. Griffiths (see Griffiths, 2, 3, 4, 5), each collection being fixed and preserved on the spot in 2 per cent formaldehyde solution. The identification of the Rotifers was carried out by Mr. F. E. Cocks.

The pools range in size from about a quarter of an acre (0·1 hectares) to 180 acres (7·28 hectares), and in depth from about three to twenty feet (1 to 6 metres). The plankton is of the benthoplanktonic rather than of the limnoplanktonic type (see Griffiths, 4, p. 209; Fritsch, 1, p. 245). The first twelve pools of the series recorded in the Table are situated on, or derive their water-supply from, moorland areas, whereas the remaining sixteen pools, nos. 13 to 28, lie on ordinary cultivated lowland areas. The exceptions are no. 5, Whittledene Reservoir, which receives a mixture of upland water and lowland water, and no. 27, Bulmershe South Pool, which lies in an area with Sphagnum bogs adjacent (see Griffiths, 3, p. 2). The first twelve pools are characterized by the frequent presence of desmids of the benthoplanktonic type, together with *Ceratium hirundinella*, *Asterionella*, and Myxophyceae, and by the absence of *Pandorina*, *Pediastrum Boryanum*, *Scenedesmus* and other Autosporineae, whereas the other sixteen pools are the reverse (see Table, pp. 466–8).

The rotifer fauna comprises 35 genera and 75 species, of which all but *Ptygura crystallina* are free-swimming forms. The largest number of species found in any one pool was twenty-one, in no. 20, Island Pool, and the lowest was three, in no. 10, Stables Lake, and in no. 13, Capheaton Lake. The first twelve pools (excluding no. 5) have an average of six species per pool; the last sixteen (excluding no. 27) have eleven, or nearly twice as many. Twenty-nine species occurred in only one pool each, eleven in only two pools each; and of the other 35 species only three occurred in more than 15 pools. One species, *Keratella cochlearis*, occurred in every pool except no. 17.

Frequency Symbols :—
×, present.
a, abundant.
m, moderately abundant.
f, few.
vf, very few.
s, single specimen.

	Northumberland.																				Worcestershire.						Berkshire.	
	' Moorland ' Habitat.												Cultivated Lowland Habitat.															
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
	Sweethope.	Rothley.	Catcleugh.	Hallington.	Whittledene.	Blackburn.	Nelly's Moss, Up.	Nelly's Moss, Low.	Debdon.	Stables.	Reservoir.	Tarn.	Capheaton.	Ravensheugh.	Village.	Pond.	Ryton.	Hurcott.	Broadwaters.	Island.	Spring Grove, Up.	Spring Grove, Low.	Stanklin.	Harvington.	Wilden.	Bulmershe N.	Bulmershe S.	Whiteknights.
Phytoplankton.																												
Desmids (benthoplanktonic)	×	..	..	×	×	×	..	×	×	×	..	×	..	..	..	..	..	..	..	×	..	..	..	..	..	..	×	
Ceratium hirundinella	..	×	..	×	×	×	×	×	×	×	×	..	..	..	..	..	..	..	..	..	..	×	×	..	..	×	×	×
Asterionella gracilis	×	..	×	×	×	..	..	×	..	..	..	..	..	..	..	..	..	×	..	..	..	×						
Myxophyceae	×	..	×	×	×	..	×	..	×	..	..	..	..	..	..	..	..	..	..	×	..	×	..	×				
Eudorina	..	..	..	..	..	×	×	×	..	..	..	..	..	×	×	×	×	..	×	..	..	×	..	..	..	..	×	
Pandorina	..	..	..	..	..	..	..	..	..	..	..	..	..	×	×	×	..	..	×	..	..	×	..	..	..	..	..	×
Scenedesmus &c.	..	..	..	..	..	..	..	..	..	..	..	..	..	×	..	×	×	×	..	×	×	×	×	×	×	×	..	×
Rotifer Fauna.																												
Anureopsis fissa (Gosse)	..	..	..	..	..	..	..	..	f	..	..	..	..	..	..	s	..	..	..	..	..	..	..	..	..	m		
Ascomorpha saltans Bartsch	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	s	..	..	..	s					
Asplanchna brightwellii Gosse	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	f	..	..	..	..	f	vf				
—— *priodonta* Gosse	..	..	..	..	..	..	..	..	..	..	..	..	..	s	..	..	..	f	..	..	..	m	..	..	f	vf	m	f
Brachionus angularis Gosse	..	..	..	..	s	..	..	..	..	..	..	..	..	..	..	vf	m	f	f	..	m	f	s	vf	f	..	..	f
—— *calyciflorus* Pallas	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	vf	m	..	..	..	..	f	..	..	..	..	..	f
—— *capsuliflorus* Pallas	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	f	s	..	s	f			
Brachionus leydigii Cohn	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	vf			
—— *urceus* (Linnaeus)	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	vf												
Chromogaster ovalis (Bergendal)	..	..	..	..	..	m	..	..	f	vf																		
—— *testudo* Lauterborn	f	..	..	..	f	..	..	vf																				
Collotheca campanulata Dobie	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	vf										
—— *mutabilis* (Hudson)	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	vf	
Colurella adriatica Ehrenberg	..	..	..	..	s	..	..	..	..	..	..	..	..	..	..	..	..	..	..	f								
—— *colurus* (Ehrenberg)	..	..	..	..	s	..	..	..	..	..	..	..	..	..	..	..	..	..	vf									

Conchiloides dossuarius (Hudson)							vf		m																		vf	
Conochilus hippocrepis (Schrank)	s			m																								
—— *unicornis* Rousselet		f	a																			m		vf				
Diaschiza forficata (Ehrenberg)					s																							
—— *gibba* (Ehrenberg)																				s								
—— *sterea* (Gosse)					vf																							
—— *ventripes* Dixon Nuttall																			s	vf								
Dicranophorus auritus (Ehrenberg)																s												
Diurella brachyura (Gosse)																s												
—— *porcellus* (Gosse)					f														s	f								
—— *stylata* Eyferth																			s				m			vf	f	
Eosphora melandocus (Gosse)																						s						
Euchlanis dilatata Ehrenberg		s			vf											f				f			vf		vf			
—— *pyriformis* Gosse																							f					
Filinia brachiata (Rousselet)																		f										
—— *longiseta* (Ehrenberg)															m			a	s			vf	m					f
—— *passa* (Müller)																s		f										
Gastropus stylifer Imhof					vf																		m			f	vf	
Keratella cochlearis (Gosse)	m	f	vf	f	f	a	m	m	m	m	f	f	f	f	a	f		f	m	m	f	a	m	vf	m	f	m	a
—— *quadrata* (Müller)					f								f	f	vf	m	m		f	f	f	f	a	vf	f	f		m
—— *serrulata* (Ehrenberg)												vf																
Lecane depressa (Bryce)									f																			
—— *flexilis* (Gosse)																				vf								
—— *ligona* (Dunlop)												vf																
—— *luna* (Müller)					f									s						m								
Lepadella ovalis (Müller)																			s									
—— *patella* (Muller)											f	s				m				f	s					s		
Monostyla cornuta (Muller)																m				f								
—— *lunaris* (Ehrenberg)				s	f				s		f									f								
Mytilina mucronata (Muller)																					s							
—— *ventralis* (Ehrenberg)																f				f							s	
Notholca foliacea (Ehrenberg)																				s								
—— *longispina* (Kellicott)	vf		f	f	f																						a	
—— *striata* (Müller)			s		s																s							
Notommata cyrtopus Gosse																				s								
—— *pachyura* (Gosse)																					s							
—— *pseudocerberus* de Beauchamp																				s								
Pedalia mira (Hudson)																							f				vf	
Pleurotrocha petromyzon Ehrenberg	s																				s							
Ploesoma hudsoni (Imhof)	f	f							f																		f	
Species carried forward .. 55	6	4	4	4	15	2	2	2	7	2	3	4	2	4	3	13	3	8	10	16	9	9	11	6	7	7	10	6

Frequency Symbols :—
×, present.
a, abundant.
m, moderately abundant.
f, few.
vf, very few.
s, single specimen.

	Northumberland.																	Worcestershire.								Berkshire.		
	'Moorland' Habitat.												Cultivated Lowland Habitat.															
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
	Sweethope.	Rothley.	Catcleugh.	Hallington.	Whittledene.	Blackburn.	Nelly's Moss, Up.	Nelly's Moss, Low.	Debdon.	Stables.	Reservoir.	Tarn.	Capheaton.	Ravensheugh.	Village.	Pond.	Ryton.	Hurcott.	Broadwaters.	Island.	Spring Grove, Up.	Spring Grove, Low.	Stanklin.	Harvington.	Wilden.	Bulmershe N.	Bulmershe S.	Whiteknights.
Species brought forward .. 55	6	4	4	4	15	2	2	2	7	2	3	4	2	4	3	13	3	8	10	16	9	9	11	6	7	7	10	6
Polyarthra euryptera Wiezejski	..	..	f	..	f	..	f	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	f	..	m	
—— *trigla* Ehrenberg	a	f	..	f	..	f	f	a	m	f	f	vf	f	f	m	f	..	f	f	..	a	f	m	..	f	f	f	m
Pompholyx complanata Gosse	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	s	..	..	..	..	..	f		
—— *sulcata* Hudson	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	f	..	f	f	..	m	m	s	..	a	..	s	m
Proales decipiens (Ehrenberg)	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	vf									
Ptygura crystallina (Ehrenberg) ..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	f												
Scaridium longicaudum (Müller) ..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	s		
Synchaeta oblonga Ehrenberg	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	m	..	f	..	..	f						
—— *pectinata* Ehrenberg	f	f	..	..	vf	vf	..	..	f	..	..	..	..	..	vf	..	..	m	..	..	f	..	m	..	..	f	..	f
—— *stylata* Wierzejski	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	f	m									
—— *tremula* (Müller)	..	..	..	..	..	.	vf	vf	..	..	..	..	..	..	f	vf	m	f	..	f	a	s						
Testudinella parva (Ternetz)	m	..	..	..	..	..	vf	..	vf	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	f	
—— *patina* (Hermann)	..	..	..	..	vf	..	.	..	..	..	..	..	..	..	..	vf	m	..	..	s	..	f	..	..	..	s		
—— *truncata* (Gosse)	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	s							
Trichocerca cristata Harring	s	..	..	..	..	..	..	..	..	..	..	..	..	..	..	s	..	..	..	..	..	..	..	..	..	s		
—— *iernis* (Gosse)	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	s	f								
—— *longiseta* (Schrank)	..	..	..	..	s																							
—— *pusilla* (Jennings)	..	..	..	..	..	..	..	..	s	..	..	s	..	..	..	..	..	..	..	..	..	vf						
Trichotria pocillum (Müller)	..	..	f	..	..	..	..	..	s	..	..	..	..	..	..	f	..	..	..	m	..	s						
—— *tetractis* (Ehrenberg)	..	..	..	..	f																							
No. of species...... 75	10	6	6	5	20	4	6	4	12	3	4	6	3	5	6	20	6	13	16	21	14	16	14	6	10	13	14	9

It is impossible to compile complete lists of Rotifers from collections which have not been specially narcotised and preserved to retain the organisms in their natural condition. Many species, mostly Bdelloids, were seen in a contracted and unrecognisable state. There were also many illoricate Rotifers which could not be identified by their external characters, and, owing to the lack of good figures of the trophi of a great number of species, they could not be identified by this important organ.

In the genera *Conochilus* and *Conochiloides*, many of the animals were sufficiently well preserved to enable the position of the ventral antennae, and their shape and number, to be clearly made out. Many of the genus *Collotheca* had been killed in an extended condition. *Collotheca mutabilis* (Hudson), which is a very rare pelagic species, was seen fully extended, so that the shape of the corona could be made out with the cilia intact, although encumbered with adhering debris. The transparent tubes were missing in every instance. In *Synchaeta stylata* Wierzejski, the spined eggs were found, which confirmed its presence.

The following species may be considered rare :—*Brachionus leydigii* Cohn, *Ascomorpha saltans* Bartsch, *Collotheca mutabilis* (Hudson), *Conochiloides dossuarius* (Hudson), *Gastropus stylifer* Imhof, *Filinia brachiata* (Rousselet), *Keratella serrulata* (Ehrenberg), *Lecane ligona* (Dunlop), *Notholca foliacea* (Ehrenberg), *Polyarthra euryptera* Wierzejski, *Ploesoma hudsoni* (Imhof), *Synchaeta stylata* Wierzejski, *Testudinella parva* (Ternetz), *Testudinella truncata* (Gosse).

The commonest and most widely distributed species are :—*Keratella cochlearis* (Gosse), *Keratella quadrata* (Müller), *Polyarthra trigla* Ehrenberg, and *Synchaeta pectinata* Ehrenberg.

The occurrence of *Polyarthra euryptera* Wierzejski is very interesting. It was described by the late Mr. Rousselet in the 'Quekett Microscopical Journal' for 1896 as a continental species unknown in England. It is apparently well distributed in this country because it occurs in pools in Northumberland, Worcestershire, and Berkshire (see Table), and it was also found by Mr. Cocks in the lake at Trent Park, North London.

Lecane ligona (Dunlop) is an exceedingly rare Rotifer. It occurred in the Tarn, Cragside, Northumberland, together with the rare *Keratella serrulata* (Ehrenberg). The Tarn is a small shallow pool, lying in a rock basin on the hill-side, and is surrounded by a fringe of *Sphagnum* and *Polytrichum*. The phytoplankton consisted of *Staurastrum brachiatum* and *Arthrodesmus incus*. The habitat is probably of the medi-acid type which Harring and Myers (7) state is favourable to the occurrence of the rarer Rotifers.

The system of nomenclature adopted in the Table on pp. 466–8 and throughout the paper is that of Harring in 'Synopsis of the Rotatoria,' Bulletin, No. 81, Smithsonian Institution, United States National Museum, 1913.

Examination of the Table shows that the species which occur sufficiently

frequently to use as indicators fall into three groups, namely :—(I) species which are confined to pools situated on or deriving their water supply from moorland habitats (nos. 1 to 12) ; (II) species confined to pools of the cultivated lowlands (nos. 13 to 28) ; and (III) species of general distribution. In some cases all the species of a genus occur in one class of pool only, but in other cases different species of the genus occur in the two types of pools.

Group I.—Rotifers confined to pools of the moorland habitat, and associated with a phytoplankton comprising desmids of the benthoplanktonic type, *Ceratium hirundinella*, *Asterionella*, and Myxophyceae.

Five species occur in these habitats :—*Chromogaster ovalis*, *C. testudo*, *Diurella stylata*, *Notholca longispina* (also in no. 27), *N. striata* (also in no. 21). The place of *N. longispina* seems fairly clear, because its only occurrence outside nos. 1 to 12 is in no. 27, Bulmershe South Pool, which is a pool with fringing *Sphagnum* bogs and a well-marked benthoplanktonic desmid flora. The case of *N. striata* is doubtful because although no. 3, Catcleugh Reservoir, and no. 5, Whittledene Reservoir, are affected by moorland water, the third habitat, no. 21, Spring Grove Upper Pool, is a small weedy lowland pool containing neither desmids nor *Ceratium* etc.

Group II.—Rotifers confined to pools of the cultivated lowlands, and associated with a phytoplankton comprising no desmids, often lacking *Ceratium*, *Asterionella*, and Myxophyceae, but uusally characterized by the presence of *Pandorina*, *Pediastrum Boryanum*, and Autosporineae.

No less than eighteen species fall into this class :—*Asplanchna brightwellii*, *A. priodonta*, *Brachionus angularis*, *B. calyciflorus*, *B. capsuliflorus*, *B. leydigii*, *B. urceus*, *Diurella porcellus*, *Euchlanis dilatata*, *Filinia longiseta*, *Gastropus stylifer*, *Keratella quadrata*, *Lecane luna*, *Lepadella patella*, *Mytilina ventralis*, *Pompholyx*, *Synchaeta oblonga*, *Testudinella patina*.

Of the above species, five also occur in no. 5, Whittledene Reservoir. The reservoir, however, is fed from a cultivated lowland area as well as from moorland areas. It was noted that the plankton contained a good deal of flocculent matter, and that a number of desmids were dead or unhealthy. This may indicate that the water is unfavourable to the moorland-water planktonts which have been carried into the reservoir.

Group III.—Rotifers occurring in both types of pool.

Three species appear to be generally distributed :—*Keratella cochlearis* in 27 pools, *Polyarthra trigla* in 22, and *Synchaeta pectinata* in 15, out of the total number of 28 pools.

Examination of the distribution of genera and species shows that while in some cases all the species of a genus are confined to one class of habitat, it is more common to find the species of a genus occupying different habitats.

Genera with species occupying the same habitat :—

1. *Chromogaster*.—*C. ovalis* and *C. testudo* both occur only in pools of the moorland-water type of habitat.

2. *Asplanchna.*—*A. brightwellii* and *A. priodonta* occur only in pools of the cultivated lowland habitat.

3. *Branchionus.*—*B. angularis*, *B. calyciflorus*, *B. capsuliflorus*, *B. leydigii*, *B. urceus* occur only in pools of the cultivated lowland habitat.

Genera with species occupying different habitats :—

1. *Keratella.*—*K. cochlearis* is generally distributed, but *K. quadrata* is confined to the cultivated lowland habitat. In the case of the latter species it is perhaps significant that the species occurs in no. 5, Whittledene Reservoir, and does not occur in no. 27, Bulmershe South Pool.

2. *Polyarthra.*—*P. trigla* is generally distributed, but *P. euryptera* appears to favour the moorland habitat. The occurrence of the latter in no. 25, Wilden Pool (and also in Trent Park Lake), however, makes it possible that it is not so much the reaction of the water as the size of the body of water which favours the occurrence of the organism. The pools in which it occurs are all of considerable size, though of varying types of water supply.

3. *Synchaeta.*—*S. pectinata* is generally distributed ; *S. oblonga* and possibly *S. stylata* favour the lowland habitat ; *S. tremula* is predominantly lowland in its choice of habitat, but shows a tendency to occur in the moorland type of habitat as well.

4. *Testudinella.*—*T. patina* appears to favour the lowland habitat, but *T. parva* tends towards the moorland habitat.

The above record of the Rotifers of the plankton of some of the lowland waters of Great Britain, imperfect though it is owing to the unsuitability of the technique of phytoplankton preservation for the proper fixation of Rotifers, nevertheless, shows clearly that these organisms are delicate indicators of the character of the habitats in which they occur. More extended surveys of the rotifer plankton are much to be desired, and it is hoped that the study of these organisms will be taken up by more of the younger students, who are much needed to augment the small number of workers on Rotifers in this country.

References to Literature.

(1) Fritsch, F. E. Some Aspects of the Ecology of Freshwater Algae. Journal of Ecology, xix, 1931, p. 245.

(2) Griffiths, B. M. August Heleoplankton of North Worcestershire Pools. Journ. Linnean Soc., Bot. xliii, 1916, p. 423.

(3) —— Heleoplankton of Three Berkshire Pools. Journ. Linnean Soc., Bot. xlvi, 1922, p. 1.

(4) —— The Phytoplankton of Bodies of Freshwater. Journal of Ecology, xi, 1923, pp. 184–213 (Ravensheugh, p. 196 ; Rothley, p. 198 ; Sweethope, p. 200).

(5) —— & Cooke, R. B. Ryton Willows Pool. Trans. Nat. Hist. Soc. of Northumberland, Durham, and Newcastle-on-Tyne, new series, vi, 1924, p. 39.

(6) Harring, H. K. Synopsis of the Rotatoria. Smithsonian Institution, U.S. Nat. Museum, Bull. 81, 1913.

(7) —— & Myers, F. J. The Rotifer Fauna of Wisconsin.—IV. Trans. Wisconsin Acad. Sci. Arts Lett. xxiii, pp. 672–5.

Contributions to our knowledge of the Colonial Volvocales of South India. By M. O. P. Iyengar, M.A., Professor of Botany, Presidency College, Madras. (From the Department of Botany, East London College, University of London.)

[Read 19 January 1933]

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The Rhizocephala in the collection of the British Museum. By Dr. H. Boschma, Leiden. (Communicated by Dr. W. T. Calman, F.R.S., F L S.)

(With 53 Text-figures, including Plate 7)

[Read 9 November 1933]

In 1928 I had the opportunity to study the collection of Rhizocephala in the British Museum (Natural History). During the time I stayed in London I made notes on many specimens in the collection, and afterwards the greater part of it was sent to Leiden for further examination. The study of this material has been delayed for various reasons, and I wish to express my thanks to Dr. W. T. Calman for his permission to keep the material much longer than at first had been arranged. To Dr. Isabella Gordon, of the staff of the British Museum, I am highly indebted for her readiness to identify a number of unnamed hosts of the parasites and for sending me material of the group which was found recently in the collections.

The material on which the present paper is based has been collected in various parts of the world. Besides a number of new species the material contains some specimens which are of special interest, viz. the type-specimen of *Sacculina rotundata*, that of *Lernaeodiscus galatheae*, and the new genus *Ptychascus*.

In the arrangement of the genera the simpler forms have been dealt with first, whilst the aberrant genus *Thompsonia* is placed at the end. Perhaps this is not altogether right, but it is difficult to decide whether *Thompsonia* is a primitive form or a highly specialized one.

I could not avoid describing a considerable number of forms as new species: consequently in the present paper, besides notes on 18 previously described species, descriptions are given of 11 new ones. Especially in the genus *Sacculina* many new species had to be recognized: among the 15 species of this genus dealt with here 9 are new.

This results from the fact that the material of the British Museum has been collected from various parts of the world, and as it is only in European waters that the Rhizocephala have hitherto been studied more or less completely, it is evident that in every collection from other parts of the world many new species may be found.

It might be doubted if it is really necessary to regard all the new species in the present paper as distinct forms. It is now firmly established that in the genus *Sacculina* there are a number of different European species, recognizable by constant characters derived from their anatomy and the structure of the chitinous coverings of the mantle. In studying the material

of the British Museum I have made use of corresponding characters, and as the differences between the species dealt with in the present paper are of the same order as those between the European species, it is evident that the new forms described here may be regarded as distinct species. In some cases the material is rather scanty, and it would have been a great advantage if more material had been available, so that the variability of the species could have been studied. The specimens of the present collection have been described more or less elaborately, but it is possible that not all the characters mentioned are of specific value.

Genus PELTOGASTER.

PELTOGASTER PAGURI Rathke.

Peltogaster paguri: Rathke (1842), Norman and Scott (1906), Pérez (1927, 1928 *b*, 1931 *c*, *d*).

For other literature on the species *cf*. Boschma (1928 *a*).

Material examined:

Starcross, Devon, Parker coll., 1884, 24 specimens, each on one host (collection Norman).

Off Sunderland, 1863, 2 specimens (collection Norman).

Firth of Forth, J. Anderson coll., 1 specimen (collection Norman).

Firth of Forth, J. Anderson, 1861, 1 specimen.

Farland Pt., Cumbrae, 20 fathoms, Aug. 24, 1888, 1 specimen (collection Norman).

All these specimens are parasites of *Eupagurus bernhardus* (L.).

The specimens are of rather uniform shape, though differing in size. The posterior end of the body is turned to the right, as usual in the species. All the specimens are mature, as they possess a well-developed mantle opening. The smallest specimens are those from off Sunderland; the greater diameter of these is 4 and 5·5 mm. respectively. In the 24 specimens from Starcross the greater diameter varies between 13 and 7 mm.

Sections have been prepared from two specimens; they show the peculiarities characteristic of the species: the simple colleteric glands and the strongly coiled vasa deferentia.

The external cuticle is smooth: it does not possess the little spines by which *Peltogaster curvatus* is characterized.

PELTOGASTER CURVATUS Kossmann.

Peltogaster curvatus: Kossmann (1873), Fraisse (1877), Smith (1906), Guérin-Ganivet (1911), Duboscq (1912), Boschma (1927 *c*).

Material examined:

Naples, 1887, 8 specimens (collection Norman).

Zoological Station, Naples, 2 specimens on one host (collection Norman).

Off Valentia, Ireland, 1870, 1 specimen.

All these specimens are parasites of *Eupagurus excavatus* (Herbst).

When seen from the dorsal or ventral surface many specimens have smooth sides, whilst in other specimens the sides show an indication of lappets, probably as a result of contraction of the mantle. All the specimens possess the small conical excrescences of the mantle which have been described by Duboscq

(1912) as a character of the species. They are also distinctly visible in the specimen from off Valentia, which proves that *Peltogaster curvatus* undoubtedly occurs in the Atlantic.

Genus Galatheascus.

The only difference between *Peltogaster* and *Galatheascus* lies in the different manner of attachment to the hosts. The long axis of *Peltogaster* lies in the same direction as that of its host, whilst in *Galatheascus* the main axis is perpendicular to that of the host. It remains questionable whether this character suffices to classify these parasites in two different genera. A similar question arises in regard to the genera *Lernaeodiscus* and *Parthenopea*, each of which is attached to the host in a different way.

The genus *Galatheascus* may be defined as follows: Body elongate oviform. Mesentery very broad, extending from the anterior to the posterior extremity. Stalk in the median part of the body or in the anterior half Mantle opening in adult specimens in the dorsal part of the anterior region. Colleteric glands small, simple, in the neighbourhood of the stalk. Testes consisting of a very short straight part at each side of the median plane, and a strongly coiled portion which passes into the vasa deferentia; the whole of the male genital organs in the region of the stalk. On the abdomen of Anomura, the long axis of the parasite perpendicular to the long axis of the host. Larvae hatching in the nauplius stage.

The diagnosis of the genus as given above differs in some respects from that given in a previous paper (Boschma, 1929) as a consequence of the study of the new species described below.

The representatives of the genus *Galatheascus* (which are hitherto known from European waters only) can be easily distinguished from the European species of the genera *Peltogaster* and *Chlorogaster* by their peculiar shape: they are much thicker in proportion to their length than the species of *Peltogaster* and *Chlorogaster*.

Galatheascus striatus Boschma.

Galatheascus striatus: Boschma (1929).

Material examined *:

Looe-Eddystone Grounds, near Plymouth, June 11, 1913, 1 specimen on *Galathea strigosa* (L.) (from the collection of the Marine Biological Association).

Diagnosis of the species (amended from Boschma, 1929).—Mantle opening extremely narrow. Stalk in the anterior half of the body. External cuticle of the mantle smooth, with shallow grooves (about 0·2 mm. apart), extending over the surface in a longitudinal direction. Internal cuticle with retinacula consisting of one to three spindles each. These spindles have a length of 20 to 25 μ.

* Recently the British Museum received another specimen of *Galatheascus striatus* from the Zoology Department of the University of Reading. This specimen, which was collected at Port Erin, Isle of Man, is attached to the abdomen of *Galathea strigosa* (L.).

From the only known specimen of this species a series of sections has been made. A detailed description of the characters of this specimen is found in the paper cited above.

GALATHEASCUS MINUTUS, sp. n.

Material examined :

Off Valentia, Ireland, 1870, 1 specimen oh *Galathea intermedia* Lillj. (collection Norman).

Oban, Scotland, 1877, 1 specimen on *Galathea nexa* Embleton (collection Norman).

Diagnosis of the species.—Mantle opening comparatively wide, at the dorsal part of the anterior region (in young specimens at the ventral part). Stalk in the median region of the body. External cuticle of the mantle smooth, without grooves.

Although the two specimens differ in size and shape they belong undoubtedly to the same species. The specimen on *Galathea nexa* is more or less elongated ; its anterior part is much thicker than the posterior part (fig. 1, *b*). This specimen has a length of 5 mm., a height of 3 mm., and a breadth of 2 mm. In the specimen on *Galathea intermedia* the dimensions are : length 2·5, height 2, and breadth 1·5 mm. approximately. The latter specimen has an

Fig. 1.—*Galatheascus minutus.* *a*, the specimen on *Galathea intermedia* ; *b*, the specimen on *Galathea nexa*. The left side of the animals is represented ; the stalk is seen below. ×6.

oval shape (fig. 1, *a*). In the larger specimen the mantle opening lies at the anterior end of the parasite, slightly turned towards the abdomen of the host ; it is surrounded by a more or less elevated ridge, so that it projects somewhat above the surface of the mantle. In the smaller specimen the mantle opening is a narrow pore which has not yet shifted towards the anterior end.

The state of preservation of the specimens is not particularly good, owing to the fact that they have been preserved for approximately sixty years. The larger specimen is somewhat better preserved than the smaller : in the larger specimen the visceral mass sufficiently shows the details of the colleteric glands and the male genital organs, whilst in the smaller specimen the latter organs have more or less loosened from the other parts of the visceral mass. In both specimens the muscles of the mantle have for the greater part vanished. Notwithstanding the insufficient preservation of the material the sections show distinctly enough that the anatomy of the species is in every respect similar to that of *Galatheascus striatus.* Testes and colleteric glands are found in the neighbourhood of the

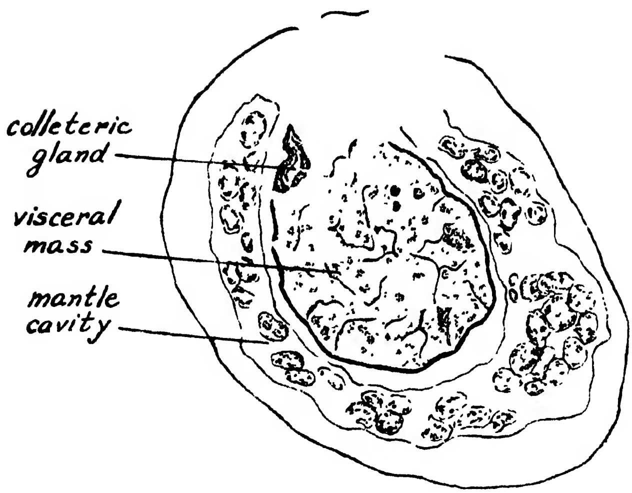

Fig. 2.—*Galatheascus minutus*, specimen on *Galathea nexa*. Transverse section. × 36.

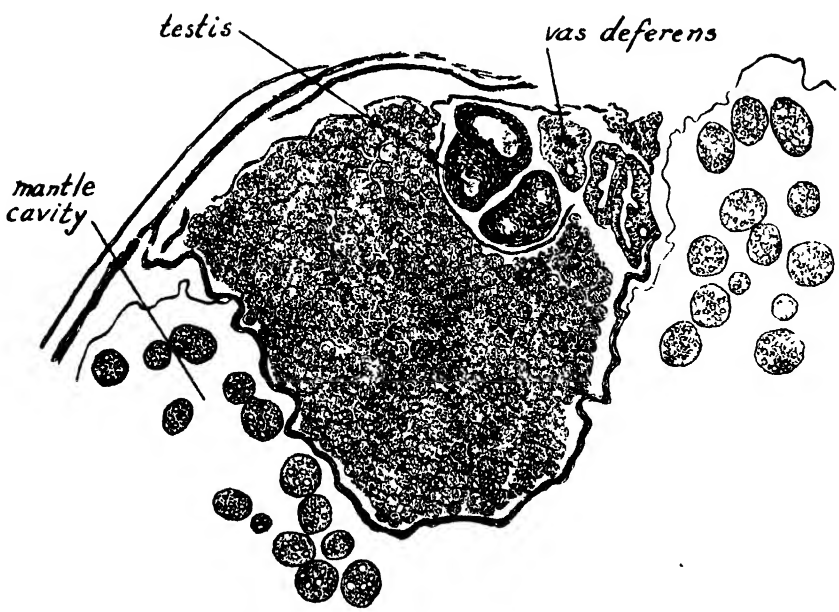

Fig. 3.—*Galatheascus minutus*, specimen on *Galathea intermedia*. Transverse section (the greater part of the mantle omitted). × 50.

stalk. The colleteric glands (fig. 2) are found at each side of the visceral mass ; they consist of small sacs with an undivided lumen. The testes (fig. 3) consist of a short straight part and a strongly coiled portion, to which the similarly coiled vas deferens is attached. The closed end of the testes is directed towards the posterior extrèmity of the body.

In comparison with the narrow mantle opening of the only known specimen of *Galatheascus striatus* this opening in the larger specimen of *Galatheascus minutus* is rather wide.

In both specimens of *Galatheascus minutus* the external cuticle of the mantle is quite smooth ; it does not show the longitudinal grooves which are found in the other species of the genus. This cuticle is very thin (thickness approximately 4 μ in the larger specimen ; in the smaller specimen it is still thinner). On the thin internal cuticle of the mantle no retinacula have been found.

It is not absolutely certain that the specimens described here as *Galatheascus minutus* are specifically distinct from *G. striatus*. They differ from the latter species in the smoothness of their external cuticle. The grooves in *G. striatus*, however, may occur in old specimens only, and if this is so the character is not valid. Notwithstanding this it remains highly probable that the two forms are specifically distinct on account of the striking differences in size.

The smaller specimen of *G. minutus* is undoubtedly a young animal, but it is not immature, as the mantle cavity contains larvae. These larvae are insufficiently preserved, so that it cannot be demonstrated whether they show any differences from those of *G. striatus*.

Genus Chlorogaster.

In 1912 Duboscq emphasized the fact that *Peltogaster paguri* and *P. curvatus* differ widely from the species until then known as *Peltogaster sulcatus* and similar forms (which were often regarded as distinct species, e. g., *P. longissimus* and *P. microstoma*). The two larger forms have a more or less curved body, which is thicker in the anterior region than in the posterior part ; they are usually solitary—only exceptionally are two or three found together on one host. On the other hand *P. sulcatus* and allied forms have an elongate body, whilst as a rule they occur in great numbers on one host. On account of these differences Duboscq founded the genus *Chlorogaster* with the type-species *C. sulcatus*. Guérin-Ganivet (1912) used the same name for this parasite. In two of my previous papers (Boschma, 1927 *c*, 1928 *a*) I kept the name *Peltogaster sulcatus* for this parasite, as the anatomy of the animals (at least as far as concerns the parts of the animal which project outside the host) does not show any striking difference from that of *P. paguri* and *P. curvatus*.

In a number of papers Pérez (1928, 1931 *a, b, c*) has shown that there are other differences between the two groups of parasites than those described by Duboscq (1912). Pérez found that the root system of *Chlorogaster sulcatus* consists of long branches with short ramifications. Each of the long branches

bears a single external sac. Furthermore, he could demonstrate that in each external sac a development of nauplius larvae takes place only once, afterwards the sacs fall off from the abdomen of the host and after the moult of the host new external sacs appear. A corresponding change takes place in the root system: after the external sacs have fallen off, their particular branch of the root system degenerates and the new external sacs originate each from a new branch, budding from the central part of the parasite.

In my opinion these differences are striking enough to justify the view that the elongate slender social forms constitute a separate genus *Chlorogaster*.

CHLOROGASTER SULCATUS (Lilljeborg).

Peltogaster sulcatus: Lilljeborg (1859), Norman and Scott (1906), Pérez (1927), Boschma (1927 *c*, 1928 *a*).
Peltogaster longissimus: Kossmann (1873), Guérin-Ganivet (1911).
Chlorogaster sulcatus: Duboscq (1912), Pérez (1928 *a*, *b*, 1931 *a*, *b*, *c*, *d*).
Chlorogaster longissimus: Guérin-Ganivet (1912).
For other literature on the species *cf.* Boschma (1928 *a*).

Material examined:

Off Valentia, Ireland, 1870, 4 specimens, detached from the host(s).
Locality unknown, 3 specimens on (?) *Eupagurus bernhardus* (L.).
Zoological Station, Naples, 7 specimens on the abdomen of a Pagurid (collection Norman).
40 miles NNW. of Achill Head, Ireland, 220 fms., 3 specimens on *Eupagurus excavatus* (Herbst) (collection Norman).
Starcross, Devon, Parker coll., 1884, 7 specimens on *Eupagurus cuanensis* (Thomps.) (3 on one host, 4 on another, collection Norman).
Starcross, Devon, Parker coll., 1884, 35 specimens on 8 hosts of the species *Eupagurus cuanensis* (Thomps.) (1 host with 9, 3 with 6, 1 with 5, 3 with 1 parasite).

The seven specimens from Starcross (3 on one host, 4 on another) are very small (greater length on an average about 3 mm.). They have a distinct mantle opening, well-developed testes and colleteric glands, but the mantle cavity does not contain eggs. In their anatomy they do not show any differences from larger specimens of *Chlorogaster sulcatus*, so that they undoubtedly belong to this species. There is, however, one peculiarity, which usually is not found in this species, viz., that the external cuticle of the mantle bears excrescences of an irregular shape (fig. 4, *a*, *b*). For comparison, parts of the cuticle of specimens from Danish waters (*cf.* Boschma, 1928 *a*) have been drawn in the same figure. Usually the cuticle in this species is quite smooth (fig. 4, *c*–*e*), but there are some specimens in which the thickness of the cuticle is very variable and therefore highly uneven (fig. 4, *f*), and other specimens in which the cuticle possesses irregular excrescences (fig. 4, *g*, *h*). In one specimen from Starcross (fig. 4, *b*) the excrescences do not differ greatly from those of the Danish specimens shown in fig. 4, *g*, *h*; in the other they are much more strongly pronounced. As they have a more or less characteristic shape only in one of the two specimens from which sections have been made, this peculiarity is probably due to individual variation. A further peculiarity of the

external cuticle of these small specimens is its thickness in comparison to the size of the animals. In full-grown specimens of *Chlorogaster sulcatus* the thickness of the external cuticle usually does not exceed 9 μ, whilst the part of the cuticle drawn in fig. 4, *a*, has a thickness of about 15 μ.

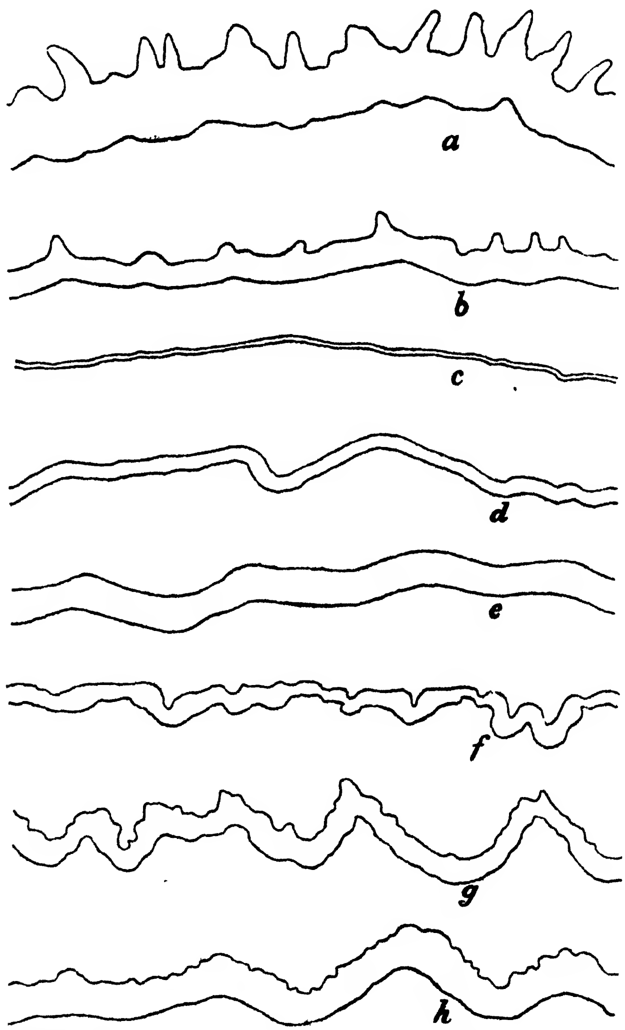

Fig. 4.—*Chlorogaster sulcatus*. Sections of the external cuticle of the mantle of different specimens. *a* and *b*, from two small specimens from Starcross; *c*, from a specimen on *Anapagurus chiroacanthus* from Danish waters; *d–h*, from specimens on *Eupagurus cuanensis* from Danish waters. $\times$ 530.

The other specimens of the collection do not differ noticeably from previously recorded specimens.

Genus PELTOGASTERELLA.

The following is an amended diagnosis of the genus, based on the description by Krüger (1912), notes and drawings by Potts (1915), and the material in the British Museum.

Gregarious, body (external sacs) elongate, more or less cylindrical. Mantle opening at the anterior extremity, stalk at the posterior extremity. Mesentery broad (as in *Peltogaster*). Testes in the dorsal part of the visceral mass (next to the mesentery), opening backwards into the mantle cavity. Colleteric glands at the lateral surfaces of the visceral mass, consisting of simple flattened cavities. Nauplius larvae. On Paguridea.

PELTOGASTERELLA SOCIALIS Krüger.

Peltogasterella socialis: Krüger (1912), Potts (1915).

Material examined:

Puget Sound, Friday Harbor, F. A. Potts leg., a great number of specimens on one specimen of *Eupagurus alaskensis* Benedict.

Diagnosis of the species.—Body elongated, anterior part somewhat thicker than the posterior part. Male genital organs and colleteric glands in the posterior half of the body. Testes and vasa deferentia forming a more or less straight tube. External cuticle thin, smooth, without excrescences.

The hermit crab with the parasites from the locality given above is probably one of the three specimens figured by Potts (1915, pl. ii, figs. 5–7). I have detached three specimens (external sacs) from their host, which have been cut into series of sections for the study of the anatomy. Two of these specimens have a length of 8·5 mm. and a thickness of 2·5 mm., the corresponding dimensions of the third specimen are 6 and 2 mm. respectively. The specimens are not altogether straight, they are somewhat bent, so that the dorsal surface is slightly concave. The stalk and mantle opening, which are found each at one extremity of the body, are shifted slightly towards the dorsal surface.

The visceral mass is broadly attached to the mantle, forming the mesentery. The musculature, except that of the sphincter of the mantle opening, is feebly developed. In the posterior half of the body, not far from the median region, at each side of the visceral mass the colleteric glands (fig. 5) are found. They are of comparatively large size in the specimens from which sections have been made: the glands consist of flattened sacs with an undivided lumen. Somewhat farther to the posterior region the testes are to be seen, one at each side of the median plane in the dorsal region of the body (fig. 6). Towards the posterior part of the body the testes gradually pass into the vasa deferentia, which, like the testes, have a more or less straight course.

The external cuticle of the mantle is very thin (about 4 μ); it is quite smooth and does not show any excrescences. Retinacula have not been found on the thin internal cuticle.

Although it is not absolutely certain that the identification of the specimens is correct, I do not hesitate to unite them with Krüger's *Peltogasterella socialis*,

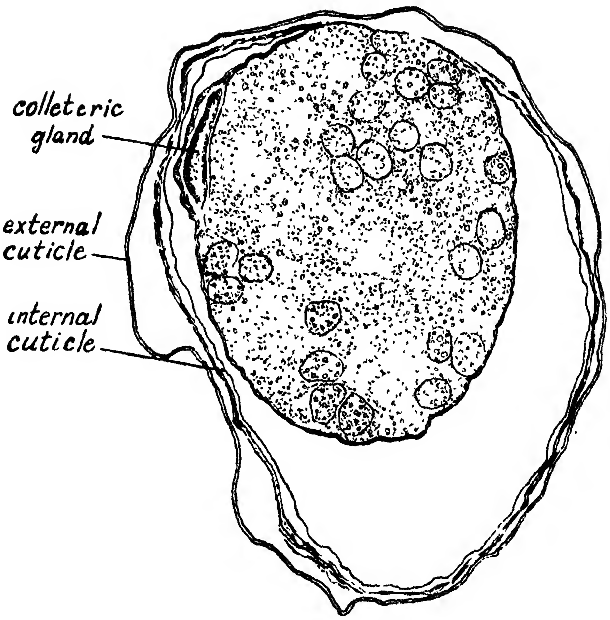

Fig. 5.—*Peltogasterella socialis.* Transverse section. ×36.

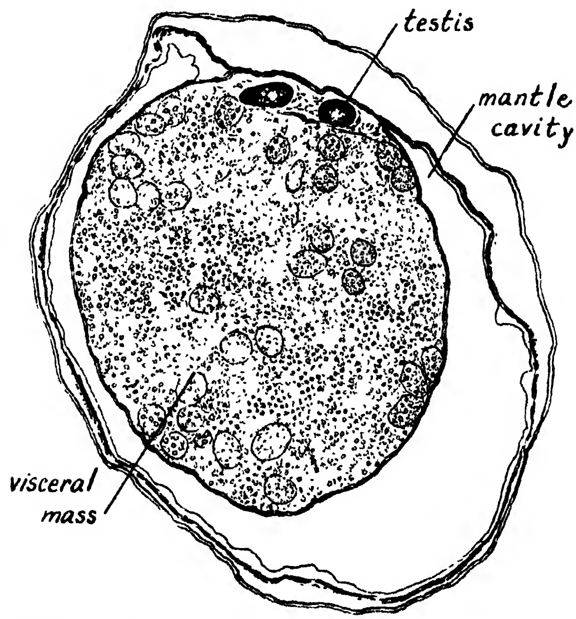

Fig. 6.—*Peltogasterella socialis.* Transverse section through a more dorsal region than that of fig. 5 (the greater part of the mantle omitted). ×36.

as was done before by Potts (1915). They possess all the characteristics of the species, and the localities are not so far distinct that this makes it improbable that they belong to the same species: Friday Harbor as well as the Siberian and Japanese localities given by Krüger are parts of the northern region of the Pacific.

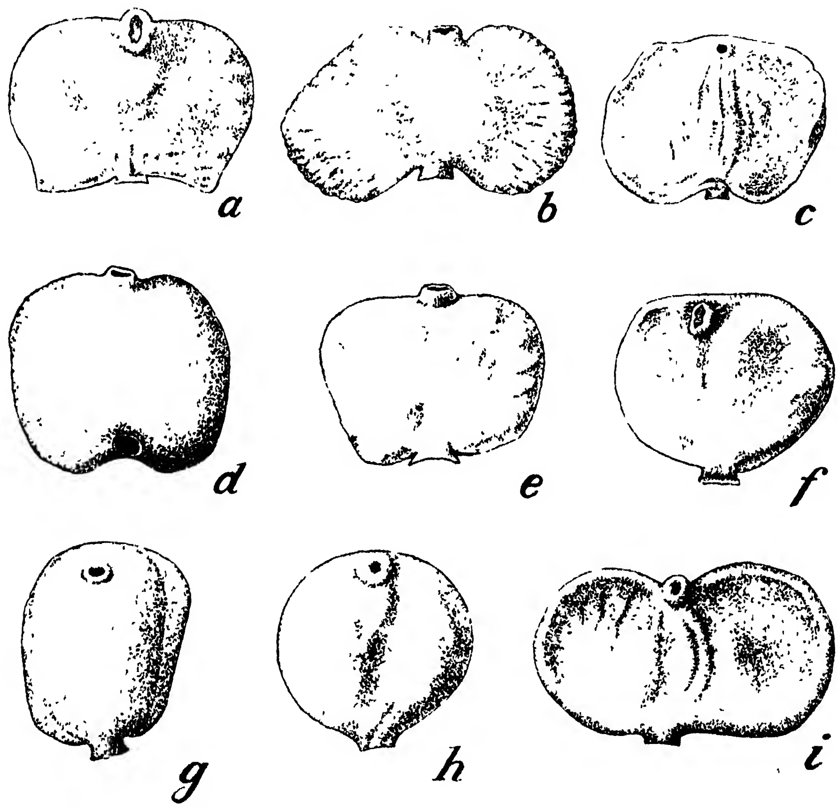

Fig. 7.—a, *Sacculina duracina*; b, *Sacculina confragosa*; c, *Sacculina pertenuis*; d, *Sacculina bucculenta*; e, *Sacculina exarcuata*; f, *Sacculina hirta*; g, *Sacculina elongata*; h, *Sacculina teres*; i, *Sacculina plana*. In all specimens the surface which was turned towards the thorax of the host is represented. The mantle opening is seen in the upper, the stalk in the lower part of the figures. *a*, × 2·8; *b*, *c*, *d*, and *h*, × 3·2; *e*, *f*, and *i*, × 2·4; *g*, × 7·2.

Genus Sacculina.

Sacculina duracina, sp. n.

Material examined:

Port Molle, Queensland, 14 faths., May 1881, Coppinger coll., 2 specimens on *Lambrus longimanus* L., presented by the Lords of the Admiralty.

Diagnosis of the species.—Male genital organs in the visceral mass. Testes more or less globular, the one behind the other, enormously enlarged. Colleteric

glands large, with a great number of tubes. External cuticle of the mantle thick (approximately 130 μ), its surface covered with spines, which are arranged in groups on common basal parts. Length of these excrescences approximately 30 μ.

The two specimens do not differ noticeably in shape and size, both of them are slightly oval with pointed edges at each side of the stalk. The breadth of one specimen is 11 mm., its height 9 mm., and its thickness 2·5 mm. In the other

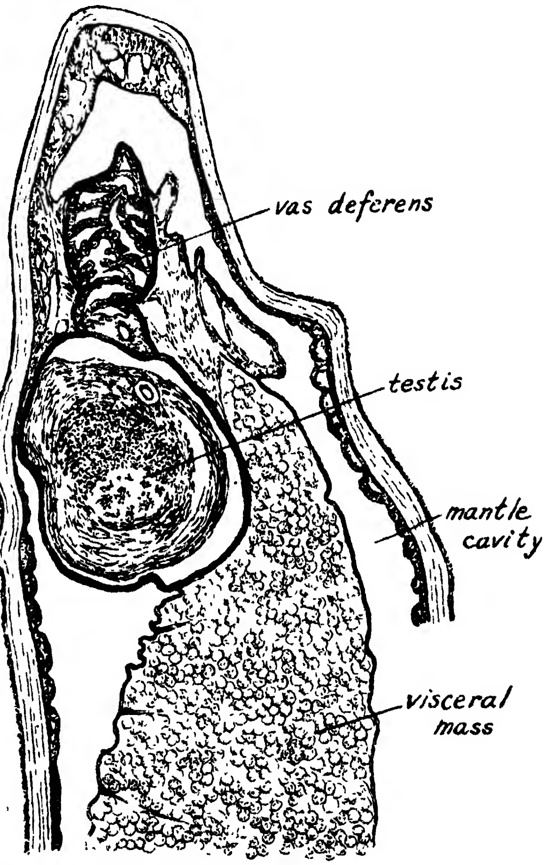

Fig. 8.—*Sacculina duracina.* Longitudinal section from a region ventral of the stalk. × 26.

specimen the corresponding measurements are 11, 8, and 3 mm. respectively. The surface of the mantle is somewhat wrinkled, the abdominal surface shows a median concavity where the parasite touched the region of the gut of its host. In one specimen (fig. 7, *a*) the mantle opening lies at the extremity of a very short tube, in the other it does not project above the surface of the mantle.

One of the specimens has been cut into a series of sections. The study of this series (*cf.* figs. 8–10) does not reveal at once whether the male genital

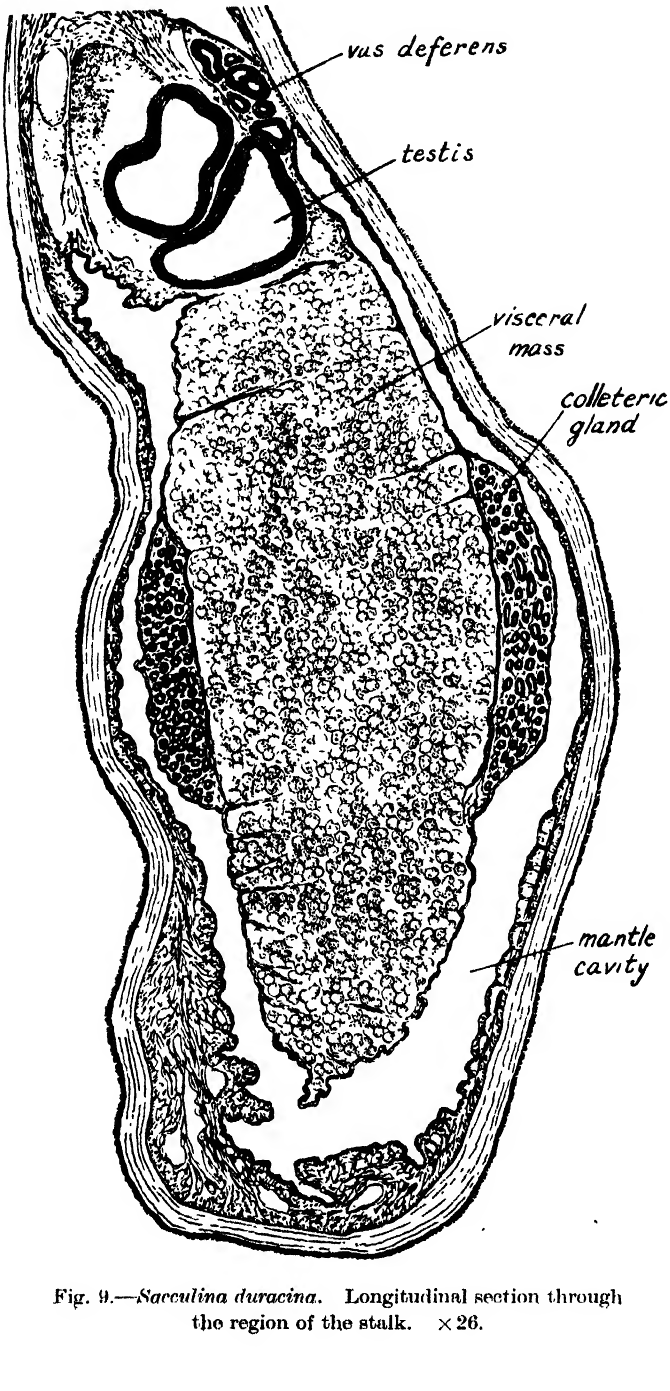

Fig. 9.—*Sacculina duracina*. Longitudinal section through the region of the stalk. ×26.

organs are found in the visceral mass or in the muscular region in the neighbourhood of the stalk. In the sections represented in figs. 9 and 10 the mantle cavity extends posteriorly about half-way round the testes, in that of the other figure (fig. 8) at one side the mantle cavity reaches somewhat farther than the centre of the testis, at the other side it extends posteriorly much farther than the vas deferens. Undoubtedly the mantle cavity originally extended farther towards the posterior part of the body, but on account of the enormous development of the testes these organs have protruded outside the visceral

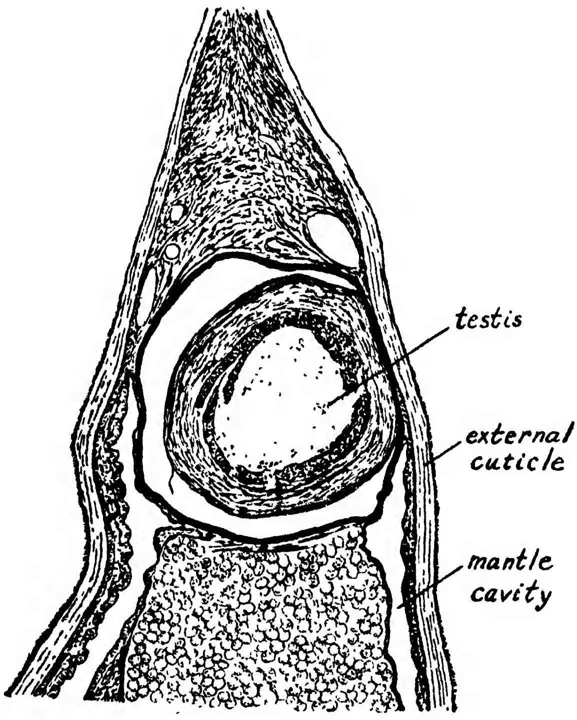

Fig. 10.—*Sacculina duracina.* Longitudinal section from a region dorsal of the stalk. ×26.

mass and have more or less fused with the mantle, causing a partial obliteration of the posterior part of the mantle cavity. Consequently the testes appear situated more or less outside the visceral mass.

Fig. 8 represents a longitudinal section through the animal, showing the ventral part of one of the testes and the corresponding vas deferens. The wall of the latter possesses a quantity of ridges by which the lumen is reduced to a narrow, more or less tortuous canal. This region of the vas deferens passes into a short tube with a rather thick wall, the lumen of the latter being covered with a distinct layer of chitin. This part of the vas deferens is in direct

contact with the testis; the layer of chitin even projects for some distance into the testis. In fig. 8 the chitinous layer is found in the upper part of the testis; above the testis the short thick-walled part of the vas deferens is visible, and above this part the extremity of the vas deferens with its numerous ridges. The testis itself is a wide sac, which has pushed aside the ovary in the visceral mass, and at the other side almost touches the external cuticle of the mantle.

Towards the median region of the body this testis diminishes in size (in the region between those of figs. 8 and 9 the size of the testis is still larger than in the first figure), and then the second testis appears (fig. 9). In this figure also a part of the vas deferens of this second testis is to be seen. Towards

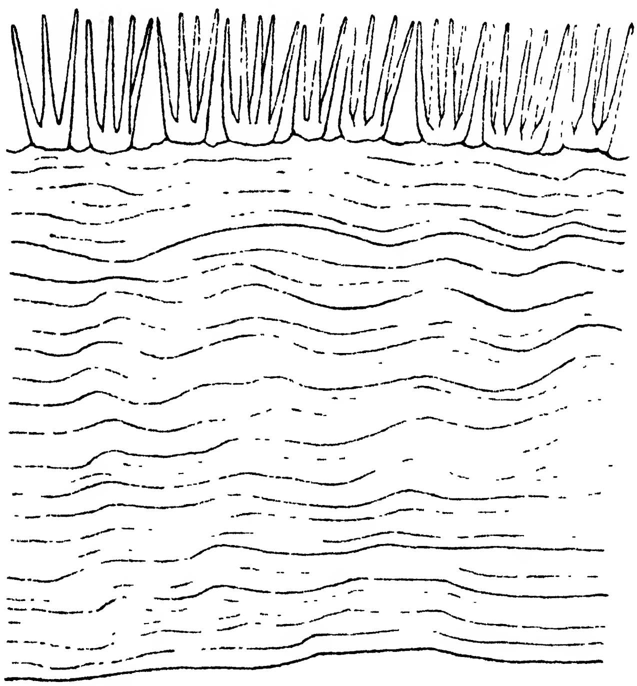

Fig. 11.—*Sacculina duracina.* Section of the external cuticle. × 530.

the dorsal region of the animal the second testis gradually increases in size; its greater diameter is reached in the region of fig. 10. Here it almost touches the external cuticle of the mantle; the mantle cavity has been completely pushed aside in the region of this testis.

The colleteric glands (fig. 9), which occupy approximately the central region of the lateral surfaces of the visceral mass, are very large. They consist of a dense mass of narrow branched tubes.

With the exception of the sphincter of the mantle opening the musculature of the mantle is not very strongly developed. In the visceral mass only a few

small muscles are seen protruding between the eggs of the ovary, originating from the thin muscular layer which covers the visceral mass.

The external cuticle of the mantle is much thicker than in most species of the genus, its thickness on an average amounts to 130 μ in the specimen from which sections have been made. In both specimens the surface of this cuticle is covered with groups of spines arranged on common basal parts. In each group there are comparatively few spines generally from three to five (fig. 11). The spines have a smooth surface; they do not bear lateral hairs. From the basal part up to the extremities of the spines the excrescences have a length of about 30 μ.

Retinacula have not been found.

It is difficult to define the character of *Sacculina duracina*, as this species is more or less an intermediate form between *S. pilosa* and *S. rotundata*. The testes are not embedded completely in the visceral mass, and, on the other hand, they are not found in the posterior part of the body outside the visceral mass. When studying the sections one gets the impression that the testes were originally contained in the visceral mass and that gradually, by developing enormously in size, they protruded from this region till they touched the mantle, causing the posterior part of the mantle cavity to disappear.

As the new species *Sacculina duracina* represents in some respects an intermediate form between *S. pilosa* and *S. rotundata* (though being specifically distinct) the differences of *S. duracina* with these other species have to be mentioned here. From typical specimens of *rotundata* the new species differs in its peculiar excrescences. When one compares these excrescences with those of the specimens of *S. rotundata* described in the present paper it is evident at first sight that the excrescences of these specimens, besides being much larger, consist of much more numerous spines. Concerning the variability of the species *S. rotundata* we have to keep in mind that it still remains a question whether the specimens put together under this name in a previous paper (Boschma, 1931 *c*) really are representatives of the same species. This question, however, cannot be solved with the material available at present: the variability of a species can be studied only with an extensive material, preferably of parasites of the same host from a more or less restricted locality. Anatomically *Sacculina duracina* can be distinguished at once from *S. rotundata* by the different position of the testes.

The specimens belonging to *Sacculina duracina* cannot be identified with *S. pilosa*, they at least do not belong to the same species as the 'Siboga' specimens (*cf.* Van Kampen and Boschma 1925, Boschma 1931 *c*). Besides the differences in the situation and shape of the male genital organs, the colleteric glands are highly different: in *S. pilosa* they are rather small and contain comparatively few tubes, whilst in *S. duracina* they are of large size and contain numerous tubes. Moreover, in the specimens of *S. pilosa* from the 'Siboga' Expedition the external cuticle of the mantle is comparatively thin (about 20 μ), whilst *S. duracina* shows exactly the reverse.

In *Sacculina vankampeni*, *S. pilosella*, and *S. compressa* (*cf.* Boschma, 1931 *c*) the male genital organs are found in the posterior part of the body, just as in *S. rotundata*. This distinguishes these species from *S. duracina*. Moreover, the three species differ from the latter in the shape of their excrescences.

SACCULINA CARCINI Thompson.

Sacculina carcini: Thompson (1836), Boschma (1927 *b*, *c*, 1928 *b*), Pérez and Basso (1928), Popov (1929).
Sacculina similis: Giard and Bonnier (1887).
Sacculina benedeni: Popov (1929).
? *Sacculina pauli*: Popov (1929).
Portunascus corrugatus: Stebbing (1893).
Grapsisaccus benedeni: Stebbing (1893).
For other literature on the species *cf.* Boschma (1927 *b*).

Material examined:

Starcross, Devon, Parker coll., 14 specimens on *Carcinides maenas* (L.) (collection Norman).
Starcross, Devon, 6 specimens on *Carcinides maenas* (L.) (collection Norman).
Polperro, Cornwall, 3 specimens on *Carcinides maenas* (L.) (collection Norman).
Wangeroog (S. of Heligoland), R. J. McKay don., Feb. 10, 1855, 1 ex. on *Carcinides maenas* (L.).
Oban, Scotland, 3 specimens on *Carcinides maenas* (L.) (collection Norman).
Starcross, Devon, 1883, 5 specimens on *Carcinides maenas* (L.) (collection Norman).
St. Leonards (near Hastings), 1888, 1 specimen on *Portunus holsatus* Fabr.
Lowestoft, B. B. Woodward don., 3 specimens on *Portunus holsatus* Fabr.
Falmouth Harbour, July 1884, 1 specimen on *Portunus arcuatus* Leach (collection Norman).
Hastings, Oct. 26, 1906, E. T. Connold don., 1 specimen on *Pisa armata* (Latr.).

The material of this species is interesting in so far as it contains a specimen on *Portunus arcuatus* Leach, a form which previously has been mentioned as a distinct species (*Sacculina similis*) by Giard and Bonnier (1887). Sections of this specimen proved that it does not differ in any respect from the specimens living on *Carcinides maenas*: the testes are united for a considerable part of their extent and occupy the same place as those of typical specimens; also the colleteric glands correspond in place, size, and structure with those of the parasites of *Carcinides maenas*.

Besides this specimen those on *Portunus pusillus* are interesting. These parasites were first mentioned by Delage (1884), and afterwards Guérin-Ganivet (1911) stated that the anatomical peculiarities of these animals correspond closely with those of the parasites of *Carcinides maenas*; accordingly he regarded them as representatives of the species *Sacculina carcini*. From one of the specimens on *Portunus pusillus* of the present material sections have been made which show also that the anatomical particulars are the same as those of typical specimens.

The specimens on *Carcinides maenas* and on *Portunus holsatus* do not differ noticeably from those previously known to occur on these crabs. The size and shape of these animals is rather variable; some have an oval shape, in

others the anterior margin possesses well-developed protrusions at the dorsal and ventral angle.

Stebbing (1893) mentions the names *Portunascus corrugatus* Giard and *Grapsisaccus benedeni* Kossmann as hosts of certain Cryptoniscidae. Evidently the parasites of *Portunus corrugatus* and of *Pachygrapsus marmoratus* are meant by these names. According to Smith (1906) the name *Sacculina corrugatus* was given by Giard to the parasite of *Portunus corrugatus*; I have, however, not been able to find this name in any of Giard's papers which I have seen. Kossmann (1872) gave the name *Sacculina benedeni* to the parasite of *Pachygrapsus marmoratus*. This form corresponds in every respect with the specimens of *Sacculina carcini* living on *Carcinides maenas*, and in all probability the parasite of *Portunus corrugatus* also does not differ from typical specimens of *Sacculina carcini*. Concerning the generic names *Portunascus* and *Grapsisaccus* I have not found any remark in publications by Stebbing and by Giard. It seems justified to regard them as synonyms of *Sacculina carcini* only.

The specimen on *Pisa armata* from the present collection is more or less globular: its dimensions are: breadth 18, height 16, and thickness about 8 mm. The region of the narrow mantle opening, which is turned towards the abdomen of the host, does not project noticeably above the surface.

In the English summary of his paper in the Russian language Popov (1929) enumerates three species of *Sacculina*, viz., *S. carcini*, *S. benedeni*, and the new species *S. pauli*. According to Popov in the Bay of Sevastopol *S. carcini* occurs rarely on *Carcinides maenas*, more often on *Pachygrapsus marmoratus*. A still more common parasite of the latter crab is *S. benedeni*. Popov does not mention the differences between these two "species" of *Sacculina*, and as I have not found any anatomical or structural differences between the two forms (*cf.* Boschma, 1927 *b*) I am convinced that they are not specifically distinct. The same probably holds good for the specimens described by Popov as *Sacculina pauli* (living on *Brachynotus lucasi*). *Sacculina pauli* differs from *S. carcini* in its mantle opening, which is extremely wide and surrounded by a high rugged cylinder. In my material of the parasites on *Brachynotus lucasi* (from the neighbourhood of Barcelona, *cf.* Boschma, 1927 *b*) this feature is not so pronounced. The anatomy and the structure of the cuticle of the specimens I have examined do not differ in any respect from those of specimens from *Carcinides maenas*. As Popov does not give any particulars of the anatomy of his specimens it remains to be proved whether they constitute a distinct species or not. For the present I am inclined to doubt this.

SACCULINA SINENSIS, sp. n.

Material examined:

Hongkong, Barney coll., 8 specimens on three specimens of *Leptodius exaratus* (M.-E.) (1 host with 5, 1 with 2, 1 with 1 parasite).

Diagnosis of the species.—Male genital organs in the visceral mass. Testes

more or less globular, completely separated. External cuticle covered with smooth slender hairs, which are loosely distributed on the surface and vary in length between 10 and 30 μ.

Four of the five specimens which are attached to the abdomen of the same host have approximately the same size, the fifth specimen is much smaller than the others (Pl. **7**, fig. 12). The approximate dimensions of the four larger specimens are: breadth 4·5 to 5 mm., height 4 mm., and thickness 2 to 2·5 mm. These specimens have a more or less roundish-oval shape; the mantle opening lies at the extremity of a small flattened tube In some of these animals the mantle is irregularly folded and wrinkled, probably as a result of preservation. The fifth specimen is more or less globular and its dimensions do not exceed 2 mm. in any direction. In the figure this small specimen is visible between two of the larger ones, at the left side of the abdomen of the host.

The two parasites which are attached to the abdomen of another host are of about equal size and shape. One of these has a breadth of 8·5 mm., a height of 6·5 mm., and a thickness of 4·5 mm., in the other specimen these dimensions are 8, 6·5, and 4 mm respectively. In these specimens the anterior part is broader than the posterior region, consequently they are somewhat triangular in shape. The mantle is more or less wrinkled like that of the other specimens. One of the two parasites is attached to the extremity of the abdomen; its chief axis is parallel to that of its host. The surface of this parasite which was lying against the thorax of the host is more or less flat, the other surface shows a short concavity caused by the pressure of the abdomen of the crab against the parasite. The other specimen on the same host is attached to the median region of the abdomen and is directed towards the right side of its host. Both specimens are as little covered by the abdomen of the crab as those represented in Pl. **7**, fig. 12.

The last specimen of the collection is intermediate in size between the other animals. It has a more or less circular shape; the dimensions are: breadth 6, height 5·5, and thickness 2·5 mm. The region of the mantle opening does not project above the surface of the mantle. The specimen is attached symmetrically to the abdomen of its host, so that a median groove is present at the posterior part of the surface which touches the abdomen of the crab.

Sections have been made from one of the larger specimens and from one of the four parasites which have a height of about 4 mm.

The male genital organs lie in the posterior part of the visceral mass (fig. 13). The testes are more or less globular; they pass rather abruptly into the vasa deferentia. The latter at first consist of narrow canals, but towards the ventral part of the animal they obtain a wider lumen of irregular shape, as a result of ridges on the inner walls. The male genital organs consequently consist of a thicker dorsal and ventral part (the testes and the terminal part of the vasa deferentia), connected by a narrow tube. In the smaller specimen the testes of both sides do not differ noticeably in size: in the larger specimen one of the testes is much larger than the other.

The colleteric glands (fig. 14) lie approximately in the central part of the lateral surfaces of the visceral mass, somewhat nearer to the anterior than to the posterior region. They contain a fairly large number of comparatively narrow tubes.

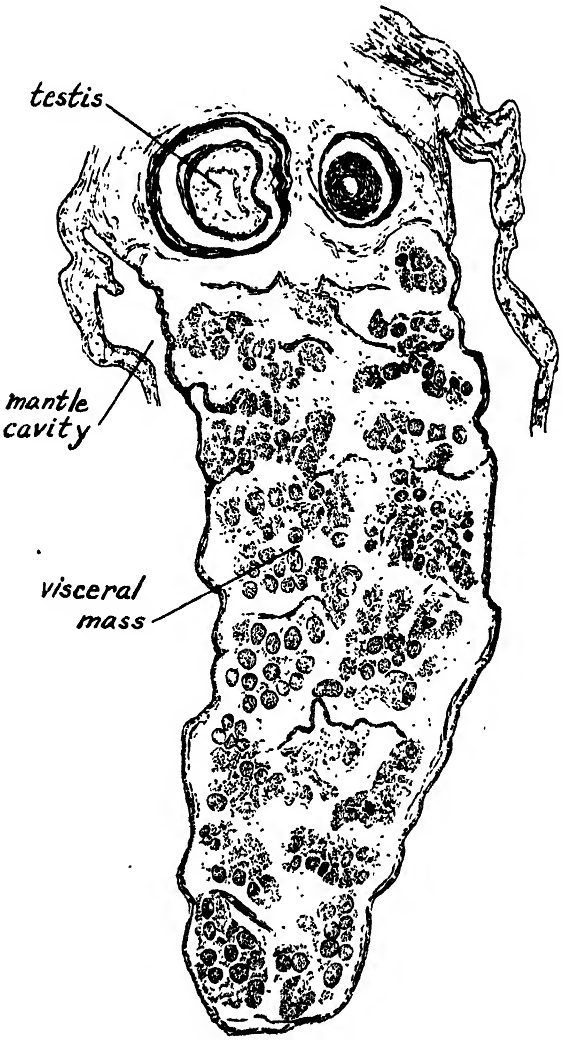

Fig. 13.—*Sacculina sinensis*. Longitudinal section through the visceral mass, showing the testes. × 36.

In the visceral mass besides the developing eggs of the ovary a few muscular elements are to be seen. With the exception of the well-developed sphincter of the mantle opening the mantle is not strongly muscular.

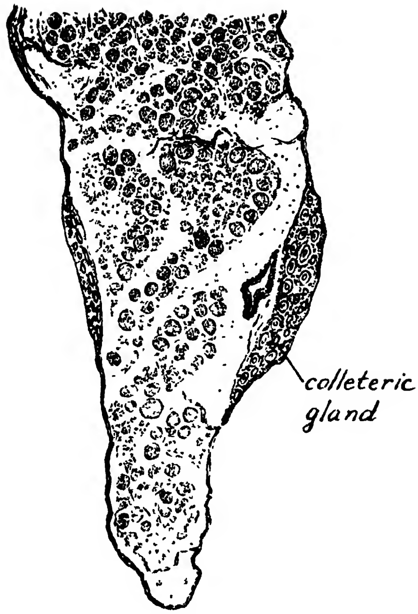

Fig. 14.—*Sacculina sinensis.* Anterior part of a longitudinal section through the visceral mass, showing the colleteric glands. × 36.

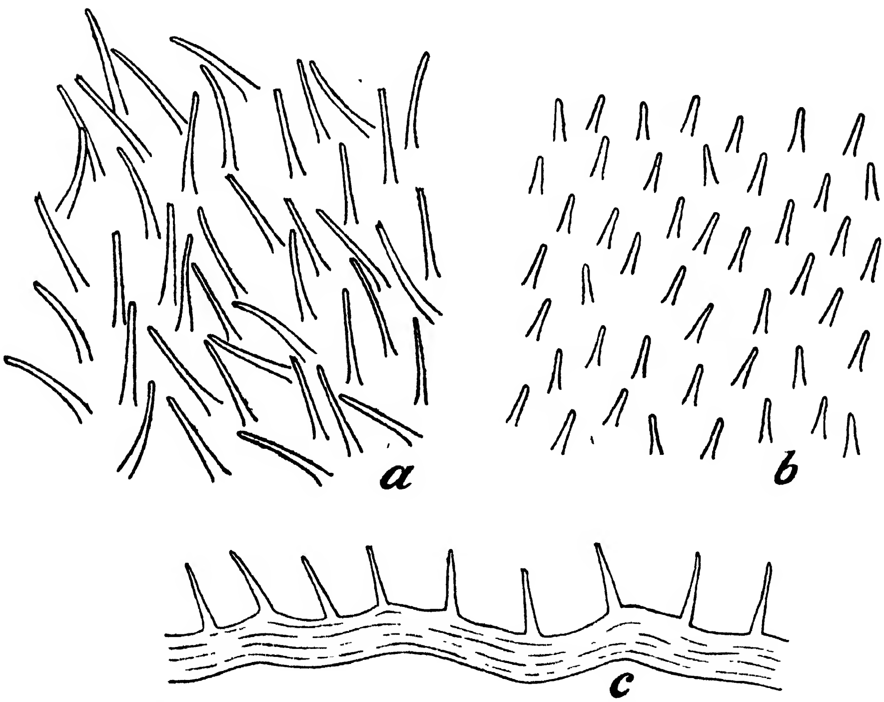

Fig. 15.—*Sacculina sinensis.* *a*, excrescences as they are distributed on the external cuticle from one of the larger specimens; *b*, the same from one of the four smaller specimens; *c*, section through the external cuticle of the same specimen. × 530.

In the larger specimen from which sections have been made the thickness of the external cuticle of the mantle varies from 15 to 40 μ, in the smaller specimen this thickness on an average amounts to 12 μ. In all specimens the external cuticle is covered with slender hairs, which differ in length in the various individuals and also in different parts of the mantle of each specimen. These hairs may attain a length of 30 μ (fig. 15 *a*), in other cases they are much shorter, even hairs of a length of about 10 μ occur (fig. 15 *b*). The hairs do not differ in structure from the main layers of the cuticle; they are comparatively loosely distributed on the surface of the cuticle. As a rule, the surface of the hairs is quite smooth, but sometimes small lateral hairs may be seen near the extremities

Retinacula could not be detected in the parts of the internal cuticle examined for this purpose.

There are a number of species of the genus *Sacculina*, viz. *S. carcini*, *S. weberi*, *S. nodosa*, *S. muricata*, and *S. microthrix*, the four last-named described by the author in previous papers (Boschma, 1931 *a*, *c*. *d*), which correspond with *Sacculina sinensis* in having the external cuticle of the mantle covered with hairs or spines and by the position of the male genital organs, which are embedded in the visceral mass. These species may be distinguished from each other as shown in the following key :—

Testes partially united.
  Excrescences of the cuticle with a small number of stiff lateral hairs, especially on the basal parts .... *weberi.*
  Excrescences of the cuticle without lateral hairs or covered with soft lateral hairs, which are more or less evenly distributed over the whole of their length.
    Excrescences short (to 18 μ) .... *carcini.*
    Excrescences longer (20–35 μ) .... *nodosa.*
Testes completely separated.
  Testes more or less globular.
    Excrescences 3–8 μ long, densely arranged on the cuticle .... *microthrix.*
    Excrescences rather loosely distributed on the cuticle, 10–30 μ long .. *sinensis.*
  Testes more or less cylindrical .... *muricata.*

Sacculina confragosa, sp. n.

Material examined :

Misaki, Japan, Alan V. Insole, Dec. 23, 1921, 2 specimens on *Pachygrapsus crassipes* Randall.

Diagnosis of the species.—Male genital organs in the visceral mass. Testes partially united. Dorsal extremity of the testes curved ventrally. Colleteric glands with a fairly large number of tubes, near the anterior part of the visceral mass. External cuticle smooth, with distinct small irregular areas with a diameter of 8–18 μ. Retinacula composed of a basal part and a small number (3 to 4) of spindles, which have a length of 10 μ approximately.

The two specimens differ in size, but not noticeably in shape. One of them

has a breadth of 19·5, a height of 13, and a thickness of 5 mm.; the corresponding dimensions of the other specimen (fig. 7, *b*) are 12, 7, and 3 mm. respectively. In both specimens the thoracal surface is more or less flat;

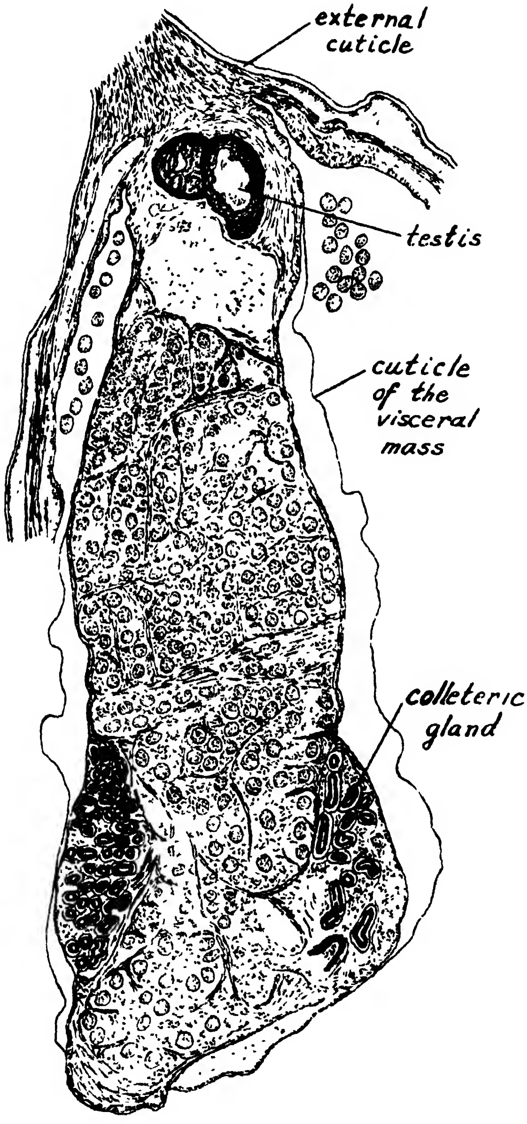

Fig. 16.—*Sacculina confragosa*. Longitudinal section through the visceral mass of the larger specimen. × 18.

the abdominal surface has a median depression, which in the larger specimen is restricted to the region of the stalk, whilst in the smaller specimen it extends

from the stalk to the neighbourhood of the mantle opening. In the median region of the body the height is smaller than that of the parts projecting at each side of the median plane of the host (i.e. the dorsal and ventral part of the parasites). The mantle opening is found at the extremity of a small tube. The surface of the mantle is more or less rough, uneven, and dimpled, especially in the ventral and dorsal regions.

The shape of the male genital organs is so peculiar that, after studying the sections of one of the animals, I thought that these organs were abnormal. Afterwards a series of sections was made from the second specimen, which show that in this animal corresponding features occur, so that the aberrant shape of the testes is in all probability a specific character. The shape of these organs may therefore be described here in some detail.

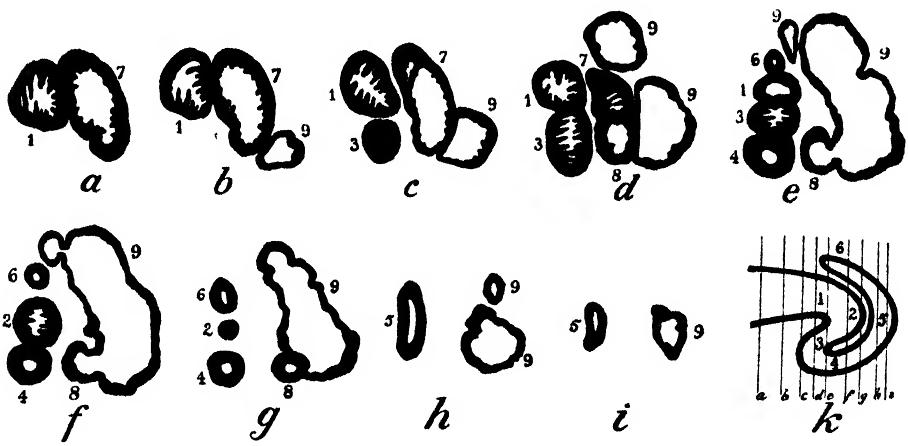

Fig. 17.—*Sacculina confragosa.* Transverse sections through the testes of the larger specimen in different regions of the body. The wall of the testes is drawn in black. *a* represents a section of the region of fig. 16, the following sections are nearer to the dorsal region, fig. *i* represents the extreme dorsal part of the testes. Fig. *k* indicates diagrammatically the plane of each of the sections. × 18.

The male genital organs are found in the posterior part of the visceral mass. The testes are for the greater part of their length more or less cylindrical, passing gradually into the vasa deferentia. The latter parts of the genital organs are of fairly large size; their lumen, however, is rather narrow, as there are numerous ridges on the inner wall. In their ventral part the two testes are closely united, but the cavities remain completely separated (figs. 16 and 17, *a*, *b*). Gradually the testes again diverge towards the lateral regions of the visceral mass; in their dorsal part the two testes do not touch each other.

In the two specimens the dorsal extremities of the testes are different. In the smaller specimen the dorsal extremities of both testes are recurved

in a ventral direction, so that in longitudinal sections through the extreme dorsal part of the testes two separate cavities at each side of the visceral mass are to be seen (more or less as in fig. 17, *d*, with the exception of the two wide cavities at the right side of the figure, indicated by 9).

In the larger specimen the shape of the testes is much more complicated (*cf*. fig. 17). The dorsal extremity of the left testis (which is drawn in fig. 17 at the left side of the figures) has approximately the shape represented diagrammatically in fig. 17, *k* (the different parts of the testis are, however, more closely joined than drawn in this diagram). The numbers in this figure correspond with those of the other figures, the lines of fig. *k* represent the sections drawn in the other figures. At its extremity the left testis first is bent in anterior direction, projecting somewhat towards the ventral region; then it is recurved and at its extremity again bent towards the dorsal region. Consequently in some of the sections the lumen of the left testis can be seen as many as four times (fig. 17, *e*). For further particulars on the shape of this testis I refer to fig. 17 The numbers 1 to 6 in figs. *a*–*i* correspond with the numbers in the diagram *k*.

The testis of the right side also is somewhat curved, but the curve does not extend towards the ventral region. it is directed more or less towards the anterior region In the sections of the dorsal part of this testis the cavity consequently has an oblong shape (this part is indicated by 7 in the figures). After this curve in anterior direction the right testis continues its course towards the dorsal region (indicated by 8 in the figures). This testis shows another peculiarity: connected with the extreme dorsal part there is a wide extension of the lumen, projecting as a voluminous pouch in a lateral direction (indicated by 9 in the figures). In figs. *e* and *f* the connection of this part with the main canal of the testis is visible.

All the sections of fig. 17 are from the dorsal half of the body, the section represented in fig. 16 lies somewhat nearer to the ventral surface than that of fig. 17, *a*.

The colleteric glands (fig. 16) are found at a short distance from the anterior part of the visceral mass. In the figure the median plane of the right colleteric gland and a part of the genital atrium of this side is visible; from the left colleteric gland a more marginal section is to be seen. The glands are fairly large and contain a great number of branched tubes.

The mantle is provided with a well-developed transverse musculature and the mantle cavity is surrounded by a strong sphincter.

With the exception of the irregular small furrows and dimples which are visible to the naked eye and cause the more or less roughened appearance of the specimens there are no excrescences of the external cuticle of the mantle. When strongly enlarged it appears to be quite smooth. On its surface the cuticle shows neat little areas with irregular contour, as they occur also in many other species of Sacculinidae with a smooth cuticle (fig. 18, *a*). The diameter of these areas varies between 8 and 18 μ.

In the larger specimen the average thickness of the external cuticle is about 25 μ, in the smaller specimen it is much thinner (12 μ).

The internal cuticle of the mantle is covered with retinacula, which are more or less evenly distributed on the chitinous layer. They consist of a basal part, which is comparatively long, and a small number (usually 3 or 4) of spindles which possess small barbs (fig. 18, *b*, *c*). In the larger specimen the spindles have a length of about 13 μ; those of the smaller specimen are somewhat shorter (9 μ approximately).

Among the species of the genus *Sacculina* which have male genital organs embedded in the visceral mass there are, besides *Sacculina confragosa*, a number of other species which have a smooth cuticle or excrescences of a very insignificant character. It is rather difficult to find specific characteristics for these

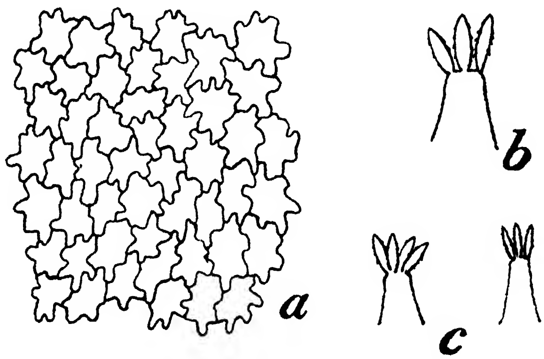

Fig. 18.—*Sacculina confragosa*. *a*, surface of the external cuticle of the larger specimen; *b*, retinaculum of the same specimen; *c*, retinacula of the smaller specimen. × 530.

species, as many of them are very similar in their internal structure. The following is a synopsis of these species :—

- Dorsal extremities of the testes curved in ventral direction, this part sometimes with a lateral pouch .... *confragosa*.
- Dorsal extremities of the testes more or less straight, not curved in ventral direction.
  - Dorsal parts of the two testes united into a single tube with a comparatively wide lumen .... *pertenuis*.
  - Dorsal parts of the testes completely separated.
    - Ventral parts of the two testes lying close together, the two testes being separated by a thin septum only, or cavities of the ventral parts of the testes communicating.
      - External cuticle with small ridges (height of these ridges 1–2 μ) ... *caelata*.
      - External cuticle smooth or somewhat rough, without ridges.
        - Ventral parts of the testes widely communicating, dorsal parts of the testes distinctly separated .... *scabra*.
        - Testes close together for the whole of their extent, ventral parts of the testes separated by a thin septum only .... *glabra*.
    - Each of the testes with a comparatively thick wall, so that also in their ventral part they are completely separated .... *bucculenta*.

One of the species in this key, *S. glabra*, has been described by Van Kampen and Boschma (1925), two in previous papers by the author (*S. caelata* Boschma 1931 *a*, *S. scabra* Boschma 1931 *c*), the other three are new species described in the present paper.

Among the six species in the key given above *Sacculina confragosa* alone shows the exceptional feature of the curved testes, and the character is perhaps of sufficient importance to warrant its separation as the type of a new genus. It cannot be placed in the genus *Drepanorchis*, on account of its complete mesentery, nor in *Loxothylacus*, for the visceral mass is directly attached to the muscular region which forms the base of the stalk. Moreover, the bent shape of the dorsal part of the testes seems to be somewhat variable: in one specimen both testes are curved in a ventral direction, in the other one is very slightly curved, the other has a double curve. For the present I keep the species in the genus *Sacculina*, though it differs from typical species of the genus in a very important character.

SACCULINA PERTENUIS, sp. n.

Material examined:

Gulf of Suez, R. McAndrew, 1 specimen on *Pinnotheres* sp.

Diagnosis of the species.—Male genital organs in the visceral mass. Testes almost completely united, forming a single cylindrical tube with two vasa deferentia. Colleteric glands more or less hemispherical, with a fairly large quantity of tubes. External cuticle smooth, without distinct areas.

The specimen (fig. 7, *c*) is much flattened, especially in the dorsal and ventral parts. Its dimensions are: breadth 9, height 6·5, and thickness 2 mm. Apart from some grooves and irregular wrinkles, the surface of the mantle is quite smooth. At the abdominal surface there is a concavity in the neighbourhood of the stalk, caused by the pressure of the region of the gut of the crab against the parasite. The region of the narrow mantle opening does not project noticeably above its surroundings.

A series of longitudinal sections has been made from the only available specimen. The most peculiar feature of the anatomy is that of the united testes. These organs are found in the posterior part of the visceral mass (fig. 19). For the greater part of their extent they form a single tube, which in the extreme dorsal part gradually diminishes in size (fig. 20, *e–h*). The two vasa deferentia are separated (fig. 20, *a*). Soon after the vasa deferentia have passed into the testes the latter organs unite and their cavities communicate with each other. At first they are more or less, though imperfectly, separated (fig. 20, *c*), but towards the dorsal part the cavity does not show any more visible traces of the fusion of the two organs.

The colleteric glands (fig. 19) are of moderate size, they contain a fairly large number of branched tubes. These glands are found in the anterior half of the lateral surfaces of the visceral mass.

With the exception of the sphincter, which surrounds the mantle cavity, the mantle is not strongly muscular.

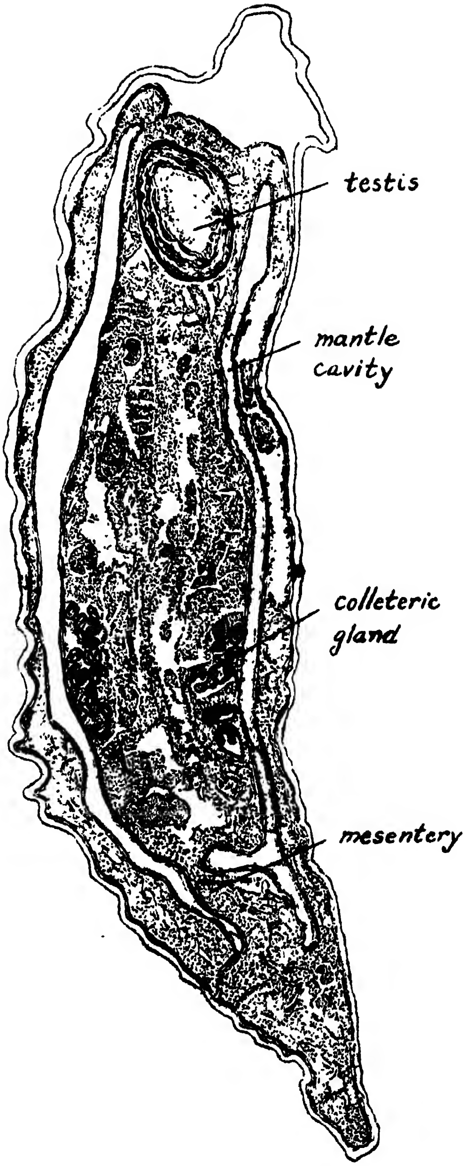

Fig. 19.—*Sacculina pertenuis*. Longitudinal section (the external cuticle of the mantle is much thinner than drawn in this figure). ×26.

The surface of the external cuticle of the mantle, which has a thickness of approximately 10 μ, does not show any special feature by which the species might be characterized. The cuticle is quite smooth, and does not show small areas such as are found in many other species of the family which have a smooth cuticle.

Retinacula could not be found on the parts of the internal cuticle of the mantle examined for this purpose.

The new species *Sacculina pertenuis* can be easily distinguished from *S. scabra* by the different shape of its testes. In *S. scabra* the testes are united in their ventral part only, the dorsal parts projecting separately in the visceral mass. The same holds true for the other species in the key on p. 498; in none of them are the testes as completely united as in *S. pertenuis*. For the other characters by which the species may be distinguished from related forms I refer to this key.

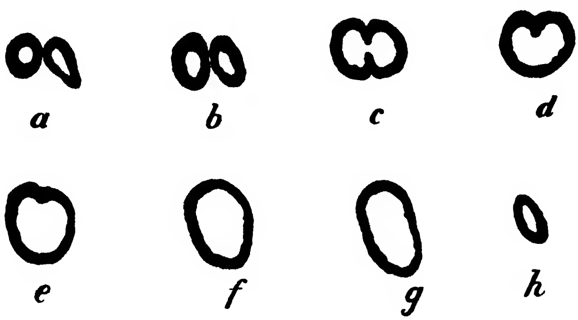

Fig. 20.—*Sacculina pertenuis*. Transverse sections through the male genital organs in different regions of the body. *a*, ventral region, showing the vasa deferentia; *h*, extreme dorsal part of the two united testes. The wall of the genital organs is drawn in black. × 16.

Sacculina bucculenta, sp. n.

Material examined:

Martaban (Lower Burmah), E. W. Oates, 1888, 1 specimen on *Micippe mascaronica* Kossm.

Diagnosis of the species.—Male genital organs in the visceral mass. Testes completely separated. Colleteric glands in the anterior half of the visceral mass, with a fairly large number of tubes. External cuticle of the mantle not very thin (thickness from 15 to 30 μ), smooth, with distinct areas (diameter of these areas 8–18 μ). Retinacula with a basal part and 4–5 spindles, which have a length of about 7·5 μ.

The specimen (fig. 7, *d*) is somewhat inflated; it has a more or less circular shape. Its dimensions are: breadth 9, height 8, and thickness 5 mm. The mantle does not possess any grooves or wrinkles, only at the abdominal surface

there is a pronounced concavity at the region where the parasite touched the ridge marking the position of the gut of the crab. The mantle opening lies at the extremity of a short compressed tube in the median plane of the parasite.

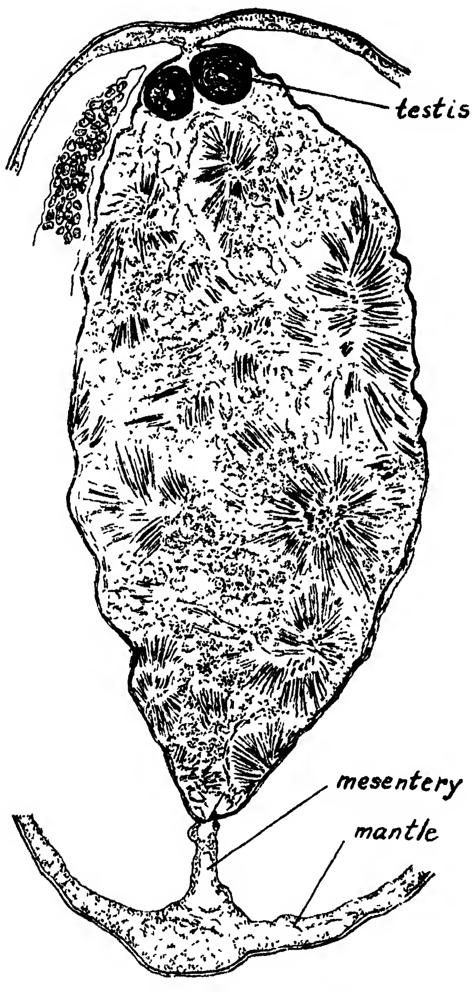

Fig. 21.—*Sacculina bucculenta.* Longitudinal section (the greater part of the mantle omitted). × 18.

A series of longitudinal sections has been prepared from the specimen. The testes are more or less cylindrical tubes which gradually pass into the vasa deferentia. The dorsal region of the male genital organ is the more voluminous part; from here they taper gradually towards the male genital openings. The two testes remain completely separated for the whole of their course, and are of about equal size and length (fig. 21).

The colleteric glands (fig. 22) are found in the anterior half of the visceral mass. Relative to the size of the whole visceral mass the colleteric glands are comparatively small. They contain a fairly large number of branched tubes.

The specimen possesses a well-developed sphincter of the mantle opening: the other parts of the mantle are not strongly muscular. The visceral mass is surrounded by a thin muscular layer. A strange peculiarity of this specimen is the large quantity of muscles in the visceral mass. There are many groups of muscles, the components each radiating from a common centre and terminating freely in the visceral mass (figs. 21, 22). A considerable portion of the visceral mass is occupied by these queer muscles. there are merely

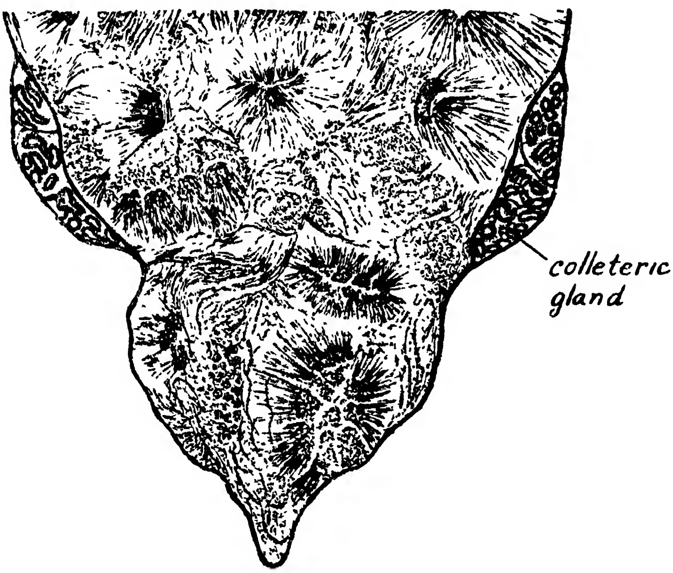

Fig 22.—*Sacculina bucculenta.* Anterior part of a longitudinal section through the visceral mass. ×26.

a few regions left where developing eggs can be seen. Probably this excessive development of the musculature in the visceral mass is not a normal character of the species. It may have arisen as a result of a kind of degeneration of the ovary of this specimen. Only a comparatively short time before the specimen was preserved, however, a great quantity of eggs had been extruded from the ovary, for the mantle cavity contains numerous embryos in the egg-membranes. The function of the ovary therefore was not diminished by the excessive development of the musculature.

The external cuticle of the mantle has a thickness of 15 to 30 μ; its surface is quite smooth. When strongly enlarged the surface is seen to be divided

into small areas with an irregular contour, which have a diameter of 8–18 μ (fig. 23, *a*).

The internal cuticle of the mantle bears retinacula which are evenly distributed on its surface. They consist of a basal part and 4 to 5 spindles on which no barbs could be detected (fig. 23, *b*). The spindles have a length of approximately 7·5 μ.

In a previous part of this paper (p. 498) I have given a key to the species of *Sacculina* which have the male genital organs embedded in the visceral mass and have a smooth cuticle or a cuticle with very insignificant excrescences. For the differentiation of *S. bucculenta* from the other species which possess these characters I refer to this key.

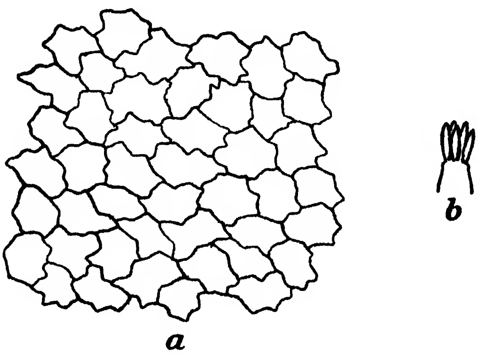

Fig. 23.—*Sacculina bucculenta.* Surface of the external cuticle of the mantle and retinaculum. × 530.

SACCULINA ROTUNDATA Miers.

Sacculina rotundata : Miers (1880), Boschma (1931 *c*).
p.p. *Sacculina pilosa* : Van Kampen and Boschma (1925), Boschma (1928 *b*).
Sacculina aculeata : Boschma (1928 *b*).

Material examined :

Malaysia, Bleeker collection, 1 specimen from the abdomen of *Eriphia laevimana* Latr.
Goram Islands, W. Stalker coll., 1 specimen on *Eriphia ? scabricula* Dana.

In a previous paper (Boschma, 1931 *b*) I described the chief particulars of seven specimens from six different localities, which I referred to the species *Sacculina rotundata*. The specimens were different in some respects, but it was impossible to decide whether some of them should be regarded as distinct species or not. The material is too scanty to study the variability of those which without any doubt belong to *S. rotundata*.

It is almost certain that both specimens in the British Museum belong to *Sacculina rotundata*. The specimen on *Eriphia laevimana* is undoubtedly the type of the species, while that on *E. ? scabricula* corresponds closely with

'typical' specimens. The chief peculiarities of each specimen are described below :—

(1) The specimen on *Eriphia laevimana*.

A fragment only is present in the collection of the British Museum, viz. about half of the mantle ; the visceral mass is completely lost. The specimen is labelled : '*Saculina rotundata* from abdomen of *Eriphia laevimana* ♂, Malaysia, Dr. Bleeker's coll., 80.15.' This is sufficient evidence that the specimen is the type of *Sacculina rotundata* described by Miers (1880). It is a fortunate fact that at least a part of this specimen has been preserved, for the excrescences of the external cuticle have been described by Miers in a rather general manner. He writes (Miers, 1880, pp. 470–471) :—'The integument is armed with numerous minute spicules, which are most abundant and conspicuous near the distal opening, but quite imperceptible except under the

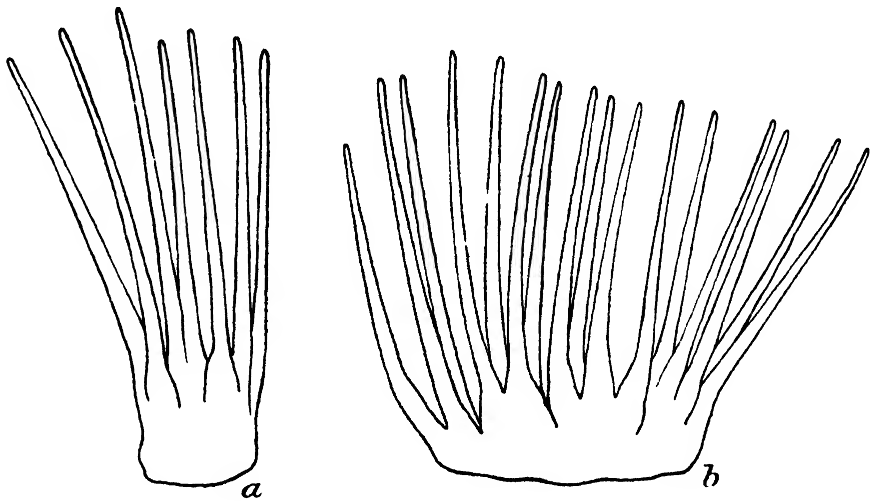

Fig. 24.—*Sacculina rotundata*. Excrescences of the external cuticle of the type-specimen. × 530.

microscope. They seem to be rooted in the cellular tissue, beneath the outer cuticle, and furthermore differ from the spinules of *S. corculum*, and more nearly resemble the infra-cuticular spicules of *S. crucifera*, Kossmann, in being very slender, not broader at base ; their apices are somewhat blunt. Such, at least, is the form of spicules taken from the vicinity of the distal opening of the sac (pl. xv, fig. 19)'. In these statements no mention has been made of the arrangement of the excrescences in groups on common basal parts, and also Miers's figure does not show distinctly that such an arrangement exists.

The part of the mantle which has been preserved is very brittle, but the excrescences are distinctly visible. They consist of a rather large number of long blunt spines, which are arranged on a common basal part (fig. 24).

In the portions of the cuticle examined in this respect the length of the excrescences (from the base up to the extremities of the spines) varies from 90 to 120 μ.

Retinacula could not be found.

The anatomy of the specimen is completely unknown. Miers does not give any details, and, as stated before, the visceral mass is now lost. Notwithstanding this, it is almost certain that *Sacculina rotundata* has the characters

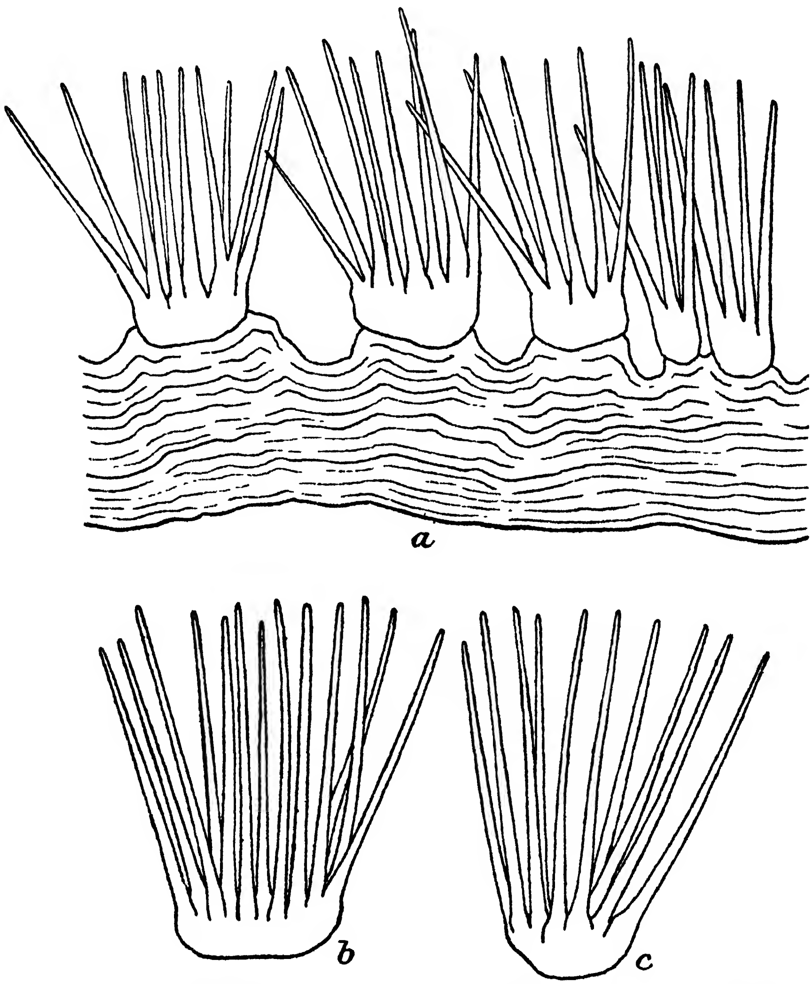

Fig. 25.—*Sacculina rotundata*. Section through the external cuticle, and excrescences from another part of the cuticle of the specimen on *Eriphia ? scabricula*. × 530.

given in a previous paper (Boschma, 1931 *c*). In three specimens identified as *S. rotundata* (one from the 'Siboga' Expedition and two from the Leiden Museum), all of which were parasites of *Eriphia laevimana*, the excrescences of the cuticle are shaped almost exactly like those of the type-specimen, which

also was a parasite of *Eriphia laevimana*. When two or more specimens of *Sacculina* are parasites of the same host this fact does not yet indicate that they belong to the same species, but in this case the fact affords strong evidence of their identity. The excrescences of the cuticle correspond so closely in the four parasites from the same host that we may safely conclude that the anatomical characters of the type must have been like those of the other specimens, in which it could be studied.

(2) The specimen on *Eriphia ? scabricula*.

The parasite has a more or less oval shape, its dimensions are: breadth 6, height 4, and thickness 2·5 mm. The surface of the mantle shows some grooves, but there is not a concavity in the abdominal surface, owing to the fact that the parasite was attached near the extremity of the abdomen of the host, so that it was not covered by this part. The mantle opening lies on the thoracal surface, not far from the anterior margin; its surroundings do not project above the rest of the mantle.

As in the other specimens of *Sacculina rotundata* the male genital organs are found in the vicinity of the stalk, embedded in the muscular tissue between the stalk and the mesentery. One of the testes is somewhat larger than the other. The comparatively flat colleteric glands occupy the central parts of the lateral surfaces of the visceral mass. These glands contain a fairly large number of branched tubes.

The external cuticle of the mantle has a thickness of about 40 μ, it bears excrescences of the typical shape. The length of these excrescences (from their basal part to the extremities of the spines) may amount to 90 μ; in some parts of the mantle, however, they are much shorter. Usually the excrescences are composed of a large number of spines, but in some parts of the mantle they are somewhat smaller and possess a few spines only (fig. 25). The spines have a blunt extremity and do not bear lateral hairs.

There are no retinacula on the parts of the internal cuticle examined for this purpose.

Sacculina exarcuata Kossmann.

Sacculina exarcuata: Kossmann (1874), Boschma (1927 *a*).

Material examined:

Shanghai, Jamrach, 1 specimen on *Lambrus validus* de Haan.

Diagnosis of the species.—Male genital organs in the posterior part of the body, outside the visceral mass. Testes more or less cylindrical, completely separated, gradually passing into the vasa deferentia. Colleteric glands almost hemispherical, in the central region of the lateral surfaces of the visceral mass. External cuticle covered with hairs or papillae which differ somewhat in length and shape in different specimens: usually they have a length of 18 μ approximately, in some specimens they are very short (12 μ) or very long (to 35 μ). Retinacula usually with a single spindle, sometimes with two or three. The length of the spindles varies between 13 and 23 μ; they do not bear barbs.

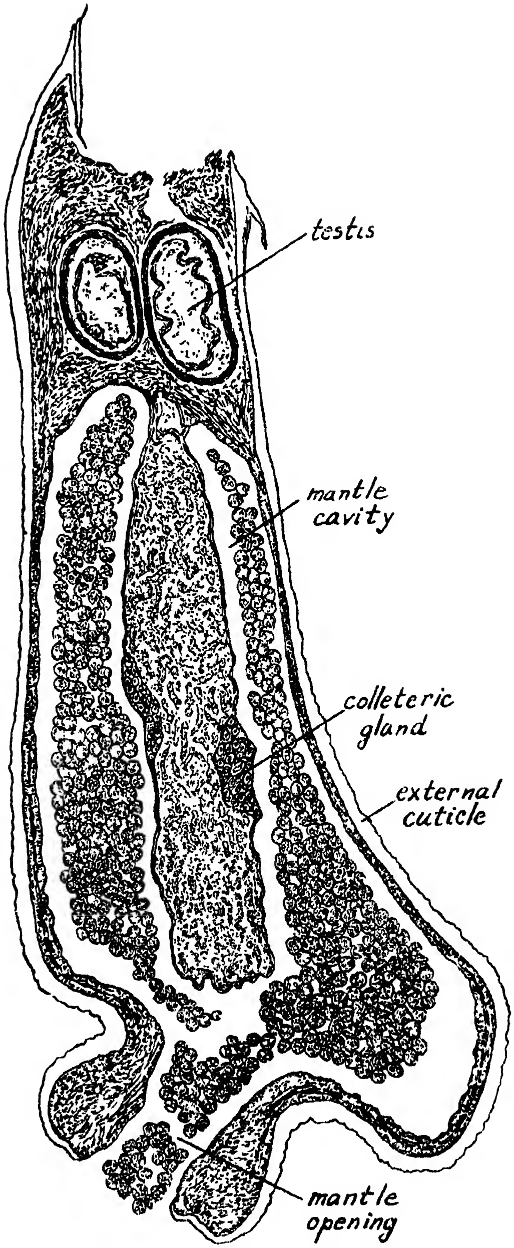

Fig. 26.—*Sacculina exarcuata*. Longitudinal section. ×18.

The diagnosis given above is partially based on the specimen in the British Museum, partly on specimens to be described in a later paper from the collection of the Museum of Comparative Zoology at Harvard College, Cambridge, Mass.

The specimen in the British Museum (fig. 7, *c*) has a breadth of 12, a height of 9, and a thickness of 4 mm. It has a more or less oval shape and a comparatively smooth surface. The surface which was turned towards the abdomen of the host shows a concavity caused by pressure of the median ridge of the abdomen of the crab. The mantle opening lies at the extremity of a short conical tube at the anterior margin.

From this specimen a series of longitudinal sections has been made, which shows that the male genital organs are found outside the visceral mass. These organs (fig. 26) occupy the central part of the muscular region between the stalk and the visceral mass. The testes are short, but more or less cylindrical, the vasa deferentia are narrow straight canals. At the place of connection of these canals with the testes there is a slight curve in a lateral direction. Both testes are of approximately equal size; their lumen is rather wide, but not enlarged excessively.

The colleteric glands (fig. 26) are situated at a short distance from the central parts of the lateral surfaces of the visceral mass, somewhat nearer to the anterior than to the posterior part. They are of moderate size and consist of numerous branched tubes. In the specimen from the British Museum these glands do not contain any chitinous matter. Probably a very short time before the parasite had been preserved the eggs had been extruded from the ovary into the mantle cavity, so that the formation of a new chitinous layer in the tubes of the colleteric glands had not yet taken place. The structure of these glands is, therefore, not so distinct as in many other specimens of Sacculinidae.

The visceral mass is more or less shrivelled as a result of the extrusion of the eggs. In the greater part of the mantle there are a few muscular elements only, except in the region surrounding the mantle opening where a strong sphincter is found. In the posterior part of the body, including the parts of the mantle in the vicinity of the stalk, a well-developed musculature is also present.

The thickness of the external cuticle of the mantle varies from 40 to 120 μ. Its surface is rather dirty, but in several spots the excrescences of the cuticle are visible in sufficient detail. The cuticle is covered with hairs which gradually diminish in thickness towards their extremity and vary in length between 22 and 28 μ. These excrescences bear numerous minute lateral hairs (fig. 27, *a*, *b*).

Great numbers of retinacula are found more or less regularly distributed on the internal cuticle of the mantle (fig. 27, *c*, *d*). They do not possess a pronounced basal part, but usually consist of one spindle, sometimes of two or three. The spindles have a length of approximately 17 μ, and they are not barbed.

It is not altogether certain that the specimen dealt with here belongs to *Sacculina exarcuata*, but comparison with those in the Museum of Comparative Zoology at Harvard College makes it highly probable, especially as the specimen shows the characters of the species as given by Kossmann (1872).

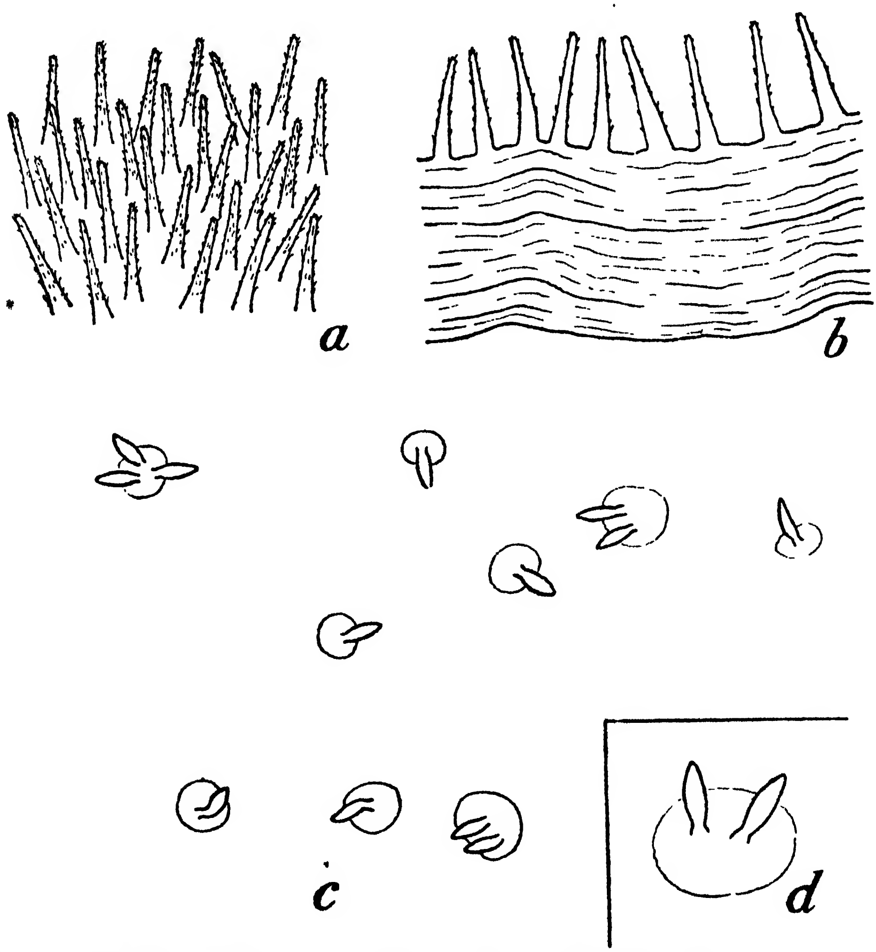

Fig. 27.—*Sacculina exarcuata*. *a*, excrescences as they are distributed on the external cuticle; *b*, section through the external cuticle; *c*, retinacula as they are distributed on the internal cuticle; *d*, a single retinaculum. *a*, *b*, and *d*, $\times 530$; *c*, $\times 290$.

In a group of species of the genus *Sacculina* the following common characters occur: Male genital organs in the posterior part of the body, testes more or less cylindrical, gradually passing into the vasa deferentia, testes of both sides completely separated, external cuticle covered with hairs or spines which have the same structure as the main part of the cuticle. Besides *Sacculina*

exarcuata this group includes *S. atlantica*, *S. hispida*, *S. comosa*, and *S. micracantha*, described in previous papers (Boschma 1927 *b*, 1928 *b*, 1931 *c*). The differential characters of these species are summarized in the following key :—

External cuticle covered with short spines (length 2–3 μ)................ *micracantha.*
External cuticle covered with longer hairs or spines or with comparatively long papillae.
  Mantle opening surrounded by a circular area with a very thin external cuticle.. *atlantica.*
  External cuticle in the neighbourhood of the mantle opening gradually diminishing in thickness.
    Excrescences long (50–70 μ).
      Excrescences with a thick basal part, covered with small lateral hairs.. *hispida.*
      Excrescences thin, smooth .... *comosa.*
    Excrescences comparatively short (up to 35 μ long)..... .... *exarcuata.*

SACCULINA HIRTA, sp. n.

Material examined :

Japan, 1 specimen on *Cryptopodia fornicata* (Fabr.), purchased from Jamrach.

Diagnosis of the species.—Male genital organs in the posterior part of the body, outside the visceral mass. Testes more or less globular, suddenly passing into the vasa deferentia. Testes completely separated, the one much larger than the other. Colleteric glands more or less hemispherical, with a comparatively large number of tubes. External cuticle covered with hairs (length 15–24 μ), bearing small lateral hairs. Retinacula with a single spindle or with 2–4 spindles (in the latter case not united on a common basal part) ; length of the spindles about 20 μ.

The strongly flattened specimen (fig. 7, *f*) has a more or less oval shape. Its dimensions are : breadth 12, height 8·5, and thickness 2·5 mm. The surface of the mantle does not show wrinkles or grooves ; there is a ridge on the thoracal surface, running from the stalk to the mantle opening, and a corresponding concavity is found on the abdominal surface. Undoubtedly these irregularities are the result of the narrow space between the thorax and the abdomen of the crab. The mantle opening lies at the anterior part of the thoracal surface, at the extremity of a small tube.

In the longitudinal sections which have been made a striking feature is the flattened appearance of the visceral mass. The male genital organs are found outside the visceral mass, in the muscular region to which the stalk is attached (fig. 28).

The two vasa deferentia are short narrow canals, which are connected with the ventral part of the wide testes. The left testis projects much farther towards the dorsal surface than the right testis, the latter, moreover, being much smaller than the former. Fig. 29, *c*, shows the connection of the right testis with its vas deferens ; the left vas deferens passes into its testis in a plane between that of fig. 29, *d* & *e*. The left testis is enormously enlarged (fig. 29, *f*, *g*). The cavities of the two testes remain completely separated.

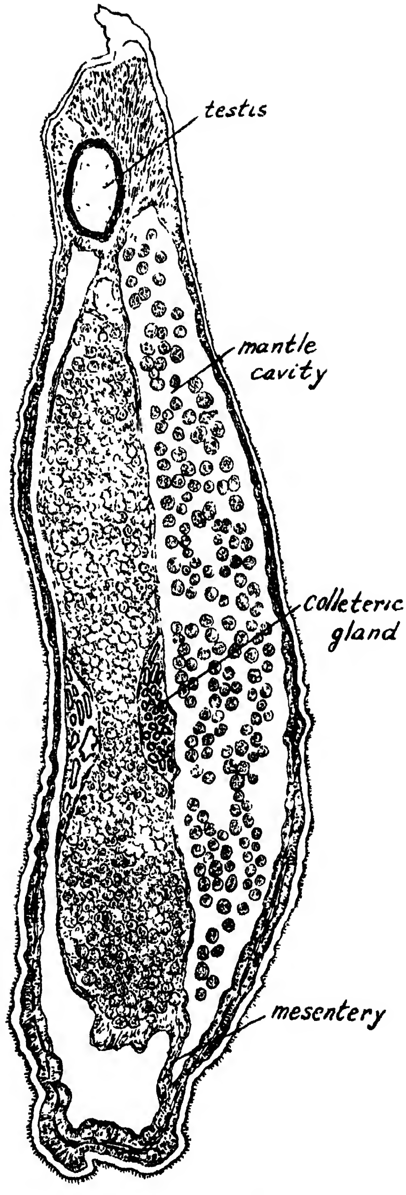

Fig. 28.—*Sacculina hirta*. Longitudinal section. ×18.

In the central region of the lateral surfaces of the visceral mass the colleteric glands are found; they lie somewhat nearer to the anterior than to the posterior part. Although these glands are of very small size (at least in comparison to those of *Sacculina eriphiae*), they contain a fairly large number of branched tubes (fig. 28).

The external cuticle of the mantle, which on an average has a thickness of 20 μ, bears numerous hairs with blunt extremities (fig. 30, *a*, *b*). They are covered with minute lateral hairs. The excrescences have a length of 15–24 μ and the thickness of their basal part may amount to 5 μ.

The internal cuticle of the mantle is covered with a great number of retinacula, which are more or less evenly distributed on this chitinous layer, but not arranged in lines (fig. 30, *c*, *d*). Each retinaculum consists of a single

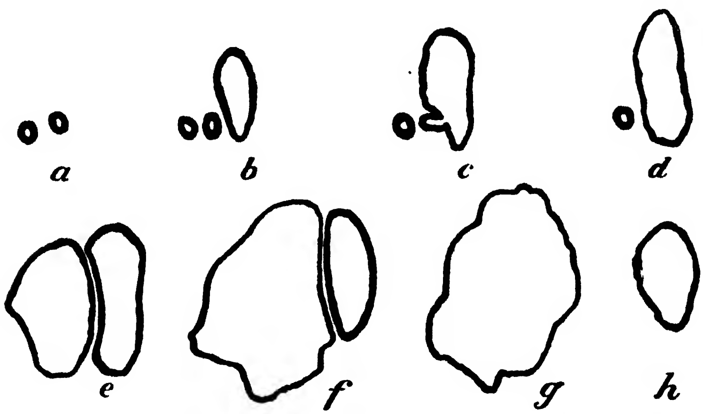

Fig. 29.—*Sacculina hirta.* Transverse sections through the male genital organs in different regions of the body. *a*, the ventral part of these organs, showing the vasa deferentia; *h*, the dorsal extremity of the larger of the two testes. × 18.

spindle, which has a length of about 20 μ and which bears distinct barbs. The spindles are directly united with the cuticle. Usually the spindles are not united into groups; only occasionally two or more are found closely together.

In many of its characters *Sacculina hirta* corresponds closely with *S. eriphiae* (Smith, 1906) and *S. inflata* (Leuckart, 1859): in these three species at least one of the testes is enormously enlarged, forming a wide thin-walled pouch; the testes (at least, the larger one) pass abruptly into the vasa deferentia. In these three species the excrescences of the external cuticle have the shape of hairs or long papillae which do not differ in structure from the main layers of the cuticle. They can be distinguished from each other by the excrescences of the internal cuticle, the retinacula. *S. inflata* does not possess retinacula; in *S. eriphiae* the spindles of the retinacula have an enormous size, whilst in *S. hirta* these spindles have the usual length (about 20 μ, fig. 30, *c*, *d*).

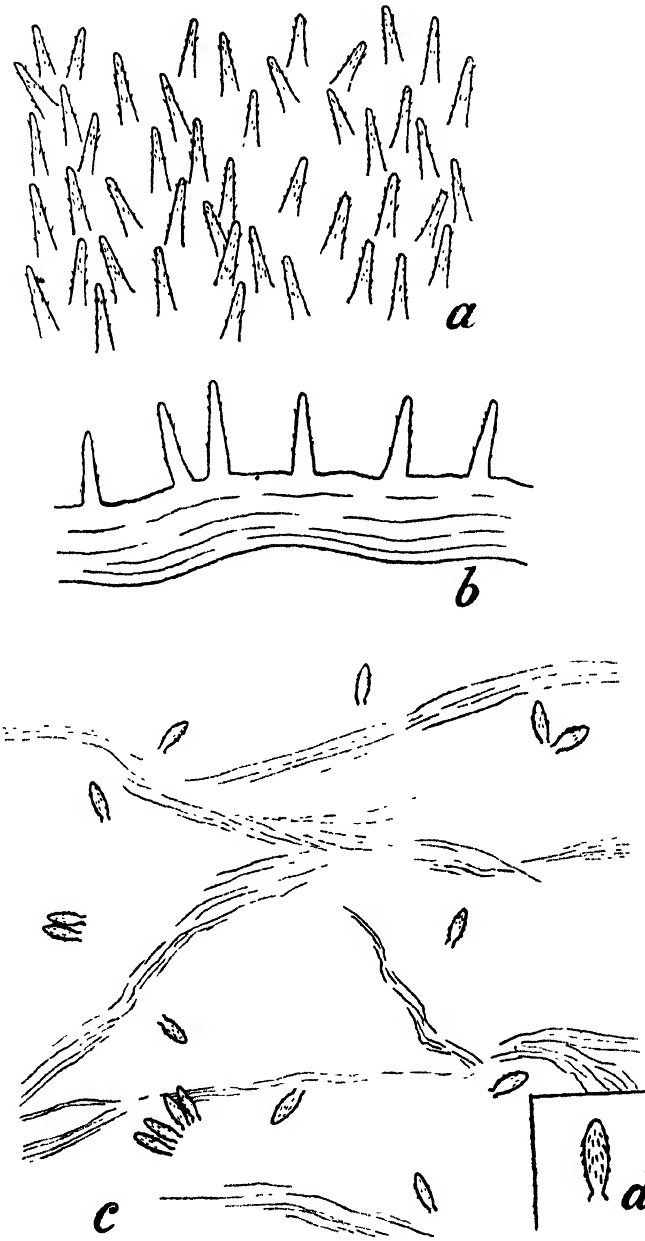

Fig. 30.—*Sacculina hirta*. *a*, excrescences of the external cuticle as they are distributed on the surface; *b*, section through the external cuticle; *c*, retinacula on the internal cuticle; *d*, a single retinaculum. *a*, *b*, and *d*, × 530; *c*, × 290.

SACCULINA INFLATA Leuckart.

Sacculina inflata: Leuckart (1859), Boschma (1927 *b*, 1931 *b*).
Sacculina triangularis: Anderson (1862), Boschma (1927 *b*).
For other literature on the species *cf.* Boschma (1927 *b*).

Material examined:
Firth of Forth, J. Anderson, 1861, 1 specimen.
Firth of Forth, J. Anderson, 1862, 3 specimens (collection Norman).
Starcross, Devon, Parker coll., 2 specimens (collection Norman).
Starcross, Devon, 4 specimens (collection Norman).
All these specimens are parasites of *Cancer pagurus* L.

In my paper on the European Rhizocephala (Boschma, 1927 *b*) I regarded the parasite of *Cancer pagurus*, *Sacculina triangularis*, as a species distinct from *S. inflata*, the parasite of *Hyas*. After this paper had appeared Professor Ashworth sent me a number of the parasites on *Cancer pagurus* from the Firth of Forth The study of the anatomy of these parasites revealed that they belong to the same species as those parasitic on *Hyas*. For reason of priority the species must be named *Sacculina inflata* (*cf.* Boschma, 1931 *b*).

The shape of the specimens in the collection of the British Museum does not differ noticeably from that of previously recorded specimens (Anderson 1862, Boschma 1931 *b*). Many specimens are more or less pear-shaped, the anterior being much broader than the posterior part; other specimens are more or less oval. The dimensions of the largest specimen in the collection are: breadth 12 mm., height 9 mm., and thickness 4·5 mm. In many specimens the surroundings of the mantle opening do not project above the surface of the mantle, and in these the mantle opening is usually small. In other specimens this opening is found at the extremity of a short tube, the opening itself being comparatively wide. The surface of the mantle is often more or less uneven on account of ridges and grooves; but these, in part at least, may be the result of contraction after preservation.

Sections have been made from a single specimen. The size, shape, and structure of the colleteric glands and the testes do not differ in any important detail from those of specimens examined previously. One of the two testes is much larger than the other, which also is in conformity with previous statements.

The excrescences of the external cuticle have the typical shape. Retinacula have not been found; undoubtedly they never occur in this species.

SACCULINA ELONGATA, sp. n.

Material examined:
'Challenger' Expedition, Stat. 191, 800 faths., 23 Sept., 1874, 2 specimens on *Ethusina gracilipes* var. *robusta* Miers.

Diagnosis of the species.—Male genital organs in the posterior part of the body, outside the visceral mass. Testes more or less globular, completely separated, vasa deferentia narrow. Colleteric glands flattened, with a comparatively

small number of tubes. External cuticle with small hairs, consisting of a broad basal part and a slender pointed sharp extremity; they may possess a few small lateral hairs. Length of the excrescences varying between 12 and 24 μ.

The two specimens were attached each to one side of the median plane of the abdomen of the same host. They are very similar in shape and size (fig. 7, *g*);

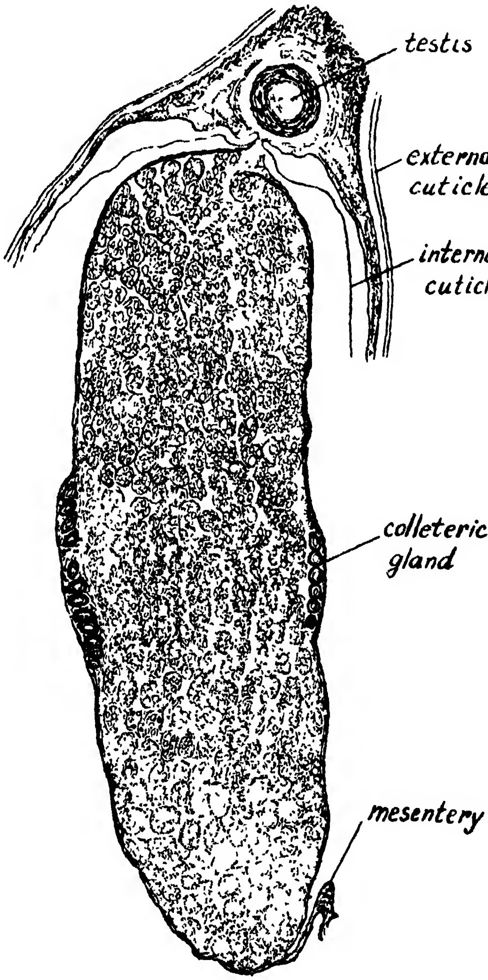

Fig. 31.—*Sacculina elongata*. Longitudinal section (the greater part of the mantle omitted). ×36.

their dimensions are: breadth 3 mm., height almost 4, and thickness 2 mm. approximately. The elongated shape may be caused by mutual pressure of the parasites against each other, but this is not certain, as each of the two animals is fairly symmetrical. The mantle opening lies at the surface which

was turned against the thorax of the host, not far from the anterior margin. It does not project noticeably above the surface of the mantle. The mantle itself is so thin that the visceral mass is dimly visible from the outside.

From one of the specimens a series of longitudinal sections has been made. The male genital organs are found in the muscular region between the stalk and the visceral mass (fig. 31). The testes are approximately globular: one of them lies nearer to the ventral region than the other, so that in none of the sections are both the testes to be seen. The figure represents a section in which the testis which lies nearer the dorsal surface is visible. The vasa deferentia are short, narrow, comparatively straight canals, which penetrate as a chitinous tube through the wall of each testis.

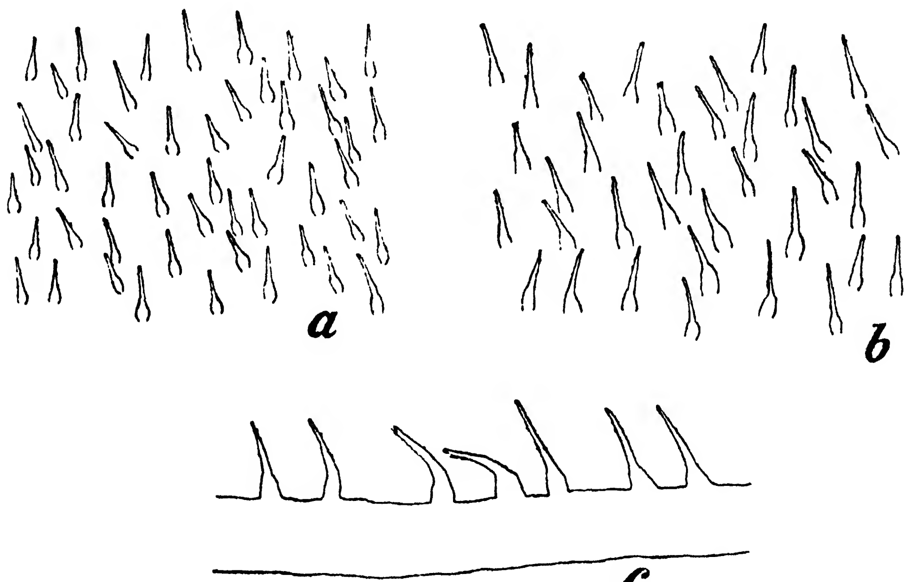

Fig. 32.—*Sacculina elongata.* *a*, excrescences on the external cuticle of one of the specimens; *b*, excrescences of the other specimen; *c*, section of the cuticle of the same specimen. × 530.

The colleteric glands lie in the central region of the lateral surfaces of the visceral mass. In these glands, which are strongly flattened, there is a small number of tubes, neatly arranged against the surface of the visceral mass (fig. 31).

The mantle is not highly muscular, except in the posterior part (the region of the stalk), and in the anterior region, where a strong sphincter surrounds the mantle opening.

The external cuticle of the mantle has a thickness of about 16 μ (in the specimen from which sections have been made). Its surface bears soft hairs

which vary somewhat in different parts of the mantle (fig. 32). The length of these excroscences varies between 12 and 24 μ; they consist of a more or less swollen basal part and a slender upper part on which sometimes minute lateral hairs may be seen.

Retinacula have not been found on the parts of the internal cuticle of the mantle examined for this purpose.

Five species of the genus *Sacculina*, viz. *S. gonoplaxae* Guérin-Ganivet (1911), *S. hirsuta* Boschma (1925), *S. spinosa* Van Kampen and Boschma (1925), *S. echinulata* Van Kampen and Boschma (1925), and *S. leopoldi* Boschma (1931 *d*), agree with *S. elongata* in the following characteristics: Male genital organs in the posterior part of the body; testes more or less globular, suddenly passing into the vasa deferentia; testes completely separated, not enlarged into a thin-walled wide sac; external cuticle covered with comparatively long hairs or spines, which have the same structure as the main layers of the cuticle. These species can be distinguished thus:—

Colleteric glands not projecting noticeably above the surfaces of the visceral mass.
- Excrescences of the external cuticle smooth or covered with very few lateral hairs.
  - Excrescences with broadened bases and pointed extremities .... *elongata.*
  - Excrescences with rounded blunt extremities .... *leopoldi.*
- Excrescences with numerous lateral hairs or spines.
  - Excrescences covered with little stiff pointed spines .... *spinosa.*
  - Excrescences covered with small soft lateral hairs.
    - Lumen of the vasa deferentia not strongly tortuous .... *gonoplaxae.*
    - Lumen of the vasa deferentia strongly tortuous .... *echinulata.*

Colleteric glands distinctly projecting above the surfaces of the visceral mass .... *hirsuta.*

The specimen of *Ethusina gracilipes* with its two *Sacculina elongata* was collected in comparatively deep water (1440 m.) in the East Indies. Another species, *Sacculina abyssicola* Guérin-Ganivet (1911), a parasite of *Ethusina abyssicola* S. I. Smith, has been taken in still deeper water (3655 and 3975 m.) off the Atlantic coast of Africa. The internal organization of *S. abyssicola* is very similar to that of *S. elongata.* The male genital organs especially correspond closely in the two species: they are found in the region between the visceral mass and the stalk, the testes being more or less globular and abruptly passing into the vasa deferentia. In *S. abyssicola* the colleteric glands are, perhaps, more strongly broadened in a lateral direction than those of *S. elongata*, but this character may be of minor importance. The same holds true for the differences in external appearance of the two species, for the two specimens of *S. abyssicola* represented on figs. 10 and 11 of the plate in Guérin-Ganivet's paper have a different shape.

The structure of the external cuticle of *S. abyssicola* is unknown, and consequently I do not feel justified in identifying the specimens obtained by the 'Challenger' Expedition with this species. Moreover, it is improbable that they are specifically identical, because the localities are widely separated;

Sacculina abyssicola is known from the Atlantic near the north-west part of Africa, whilst *Sacculina elongata* lives in the East Indies.

Among the material collected by the 'Siboga' Expedition there is a parasite on *Ethusina gracilipes* var. *robusta* from a depth of 1300 m. in Makassar Strait, which we have described as *Sacculina sulcata* (*cf.* Van Kampen and Boschma 1925, Boschma 1931 *c*). The internal anatomy of this species closely resembles that of *S. elongata* : testes and colleteric glands correspond in place, size, and structure. The external cuticle of *S. sulcata*, however, is devoid of excrescences, and, as the 'Challenger' specimens possess distinct hairs of a typical form, they must be specifically distinct from the 'Siboga' specimen, although they live on the same species of host.

SACCULINA GONOPLAXAE Guérin-Ganivet.

Sacculina gonoplaxae : Guérin-Ganivet (1911), Boschma (1927 *b*, *c*).
For other literature on the species *cf.* Boschma (1927 *b*).

Material examined :

'Porcupine,' 1870, Station 36 (Lat. N. 35° 35′, Long. W. 6° 26), 128 fathoms, 1 specimen on *Gonoplax angulata* (Penn.) (collection Norman).

Naples, 3 specimens on one specimen of *Gonoplax angulata* (Penn.) (collection Norman).

The specimen from the 'Porcupine' Expedition has an oval shape; its dimensions are: breadth 6, height 4, and thickness 2·5 mm. The surface of the mantle is smooth ; there is only a concavity in the neighbourhood of the stalk, where the abdominal surface of the parasite touched the host. The shape of the three parasites from Naples is different from that of the other specimens ; these three are more or less pear-shaped, probably on account of lack of room. The largest specimen of the three has the following dimensions : breadth 5·5, height 4, and thickness 2·5 mm. In this specimen the mantle opening is situated at the top of a short tube, in the two smaller specimens it does not project above its surroundings.

Longitudinal sections have been made from the specimen from the 'Porcupine' expedition and from one of the specimens from Naples. The anatomical peculiarities of these two specimens do not show any important differences, and, moreover, they correspond with those of the specimen from Naples which I examined some time ago (Boschma, 1927 *c*).

The male genital organs are embedded in the muscular region to which the stalk is attached. The testes are approximately globular, differing slightly in size in both specimens. The vasa deferentia are short tubes which are very slightly coiled and pass abruptly into the testes.

The colleteric glands of the 'Porcupine' specimen do not project above the surfaces of the visceral mass ; in that from Naples they form a slight elevation of the visceral mass. In both specimens these glands are found a little nearer to the anterior than to the posterior region of the visceral mass. They contain a comparatively small number of branched tubes.

In the 'Porcupine' specimen the musculature of the mantle is more strongly developed than in that from Naples. In the latter the visceral mass is rather flat, in the former it is much thicker owing to the more or less distended ovary.

The external cuticle does not differ in important details from that found in the previously known specimen. In both specimens from which sections have been made the thickness of this cuticle on an average amounts to 9 or 10 μ. The cuticle is covered with excrescences which are rather sparsely distributed on its surface: in the preparations examined they vary in length from 12 to 15 μ and bear numerous minute lateral hairs.

On the thin internal cuticle of the mantle no retinacula could be found. In all probability these excrescences do not occur in the species.

Guérin-Ganivet (1911) described the parasite of *Gonoplax angulata* as a new species, *Sacculina gonoplaxae*. He did not find the testes in his specimen, but remarks that the colleteric glands are found exactly in the central part of the lateral surfaces of the visceral mass. In 1927 I had occasion to describe a specimen of this parasite from Naples. In this specimen the colleteric glands are found somewhat nearer the anterior than the posterior part of the visceral mass. The specimen, however, showed sufficient peculiarities to regard it as a representative of a distinct species, the diagnosis of which I formulated somewhat as follows:—'Testes outside the visceral mass, in the stalk. Colleteric glands with few, rather narrow tubes. External cuticle with hairs, which are not densely distributed, and which have a length of 15–18 μ; they are covered with small lateral hairs. Retinacula unknown' (Boschma, 1927 *c*). Since then I have studied a great number of other species of *Sacculina*. The diagnosis of *Sacculina gonoplaxae* now can be given in the following manner: Male genital organs outside the visceral mass. Testes more or less globular, suddenly passing into the vasa deferentia. One of the testes somewhat larger than the other, but neither of the two enlarged into a thin-walled wide sac. Testes completely separated from each other. Colleteric glands in the central part of the lateral surfaces of the visceral mass, or (as usually in the species) somewhat nearer to the anterior region, comparatively small, with a few tubes only. These glands do not project noticeably above the surfaces of the visceral mass. External cuticle with hair-like excrescences, which have a length of 12–18 μ, and are covered with minute lateral hairs. The structure of the excrescences does not differ from that of the main layers of the cuticle. Retinacula unknown (probably not occurring in the species).

SACCULINA TERES, sp. n.

Material examined:

'Challenger' Expedition, Kei Islands, 1888, 2 specimens on one specimen of *Notopoides latus* (Henderson).

Diagnosis of the species.—Male genital organs in the posterior part of the body, outside the visceral mass. Testes completely separated, more or less globular,

the one larger than the other. Colleteric glands flat, with a comparatively small number of tubes. External cuticle covered with papillae, which at their extremities possess a number of small spines. The diameter of these papillae is 6–12 μ, their height may attain 20 μ.

The two parasites were attached to the abdomen of their host, one at each side of the median plane. They are very similar in shape and size. One of the specimens is more or less circular (fig. 7, *h*); its dimensions are: breadth 8, height 7·5, and thickness 4 mm. In the other the corresponding dimensions are: 7, 7, and 5 mm. respectively. The latter specimen is somewhat more slender in the region near the stalk, and accordingly it is more or less pear-shaped. The surface of the mantle does not show any pronounced grooves or wrinkles. The mantle opening, which lies at the anterior end of the thoracal surface, does not project noticeably above its surroundings

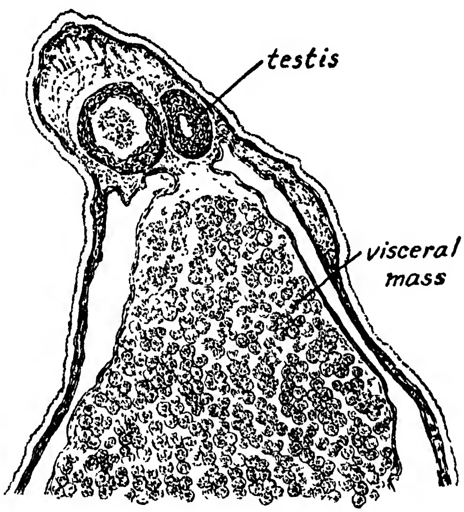

Fig. 33.—*Sacculina teres*. Posterior part of a longitudinal section. ×18.

One of the specimens has been cut into a series of longitudinal sections. The male genital organs are found in the posterior part of the body, outside the visceral mass. The testes (fig. 33) are completely separated, more or less globular. One of the testes is slightly larger than the other. The vasa deferentia are short, somewhat curved, narrow tubes, which pass suddenly into the testes.

The colleteric glands (fig. 34) lie somewhat nearer to the anterior part of the visceral mass than to the posterior region. These glands are flat organs, which do not project above the surfaces of the visceral mass. They contain a small number of branched tubes.

The visceral mass and the mantle, with the exception of the sphincter of the mantle opening, are not strongly muscular.

The external cuticle of the mantle has a thickness of about 40 μ in the specimen from which sections have been made. It is covered with typical excrescences, which vary somewhat in size and distribution in the two specimens and also in different parts of the mantle of the same specimen. These excrescences are small papillae which have the same structure as the main layers

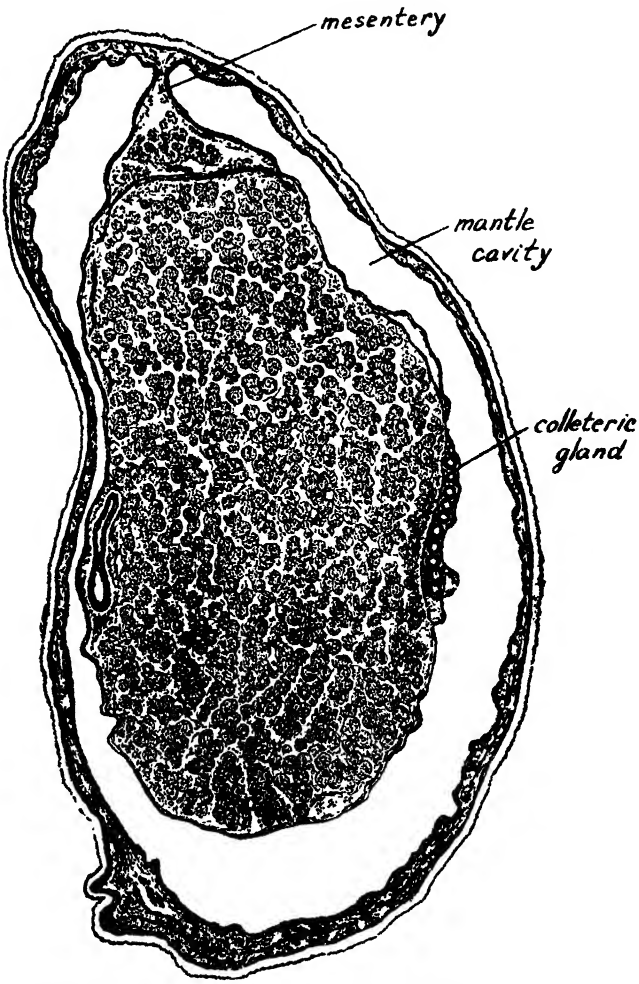

Fig. 34.—*Sacculina teres.* Longitudinal section. × 18.

of the cuticle (fig. 35). The papillae may attain a length of 20 μ; their diameter varies between 6 and 12 μ. At the centre of each papilla there is a small pit which opens at the top. The upper part of the papillae bears a fairly large number of minute pointed spines.

Retinacula have not been found in the preparations made for this purpose.

The species *Sacculina hystrix*, *S. calappae*, and *S. verrucosa*, described by Van Kampen and Boschma (1925), have many characters in common with *Sacculina teres*. In agreement with these species *S. teres* has the following peculiarities: Male genital organs in the posterior part of the body outside the visceral mass, testes completely separated; external cuticle covered with

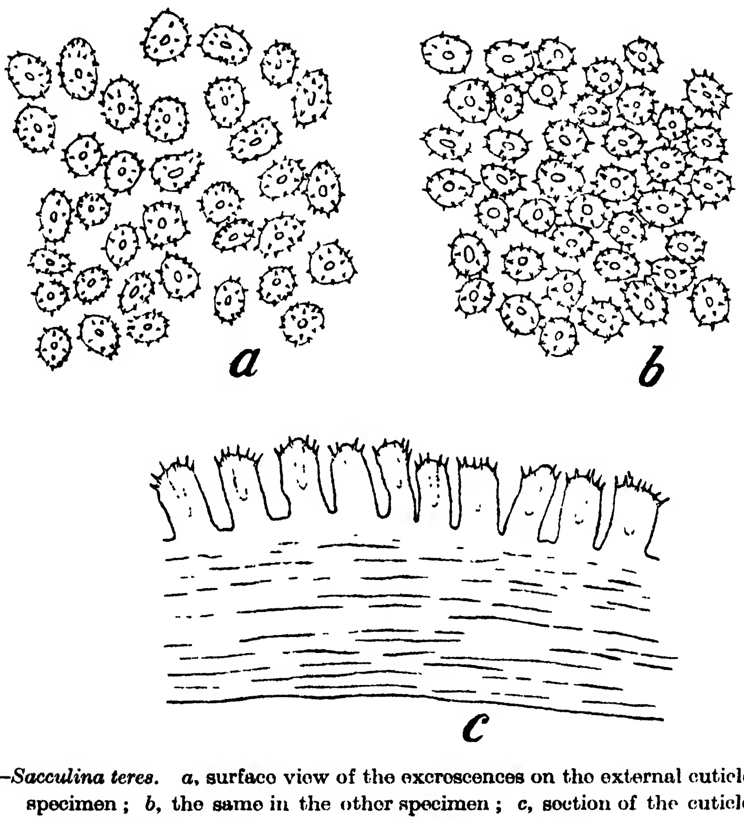

Fig. 35.—*Sacculina teres*. *a*, surface view of the excrescences on the external cuticle of one specimen; *b*, the same in the other specimen; *c*, section of the cuticle of the same specimen. × 530.

papillae or wart-like excrescences, which possess small hairs or spines, the excrescences not differing in structure from that of the main layers. *S. teres* differs from *S. hystrix* in having two well-developed testes. The shape of the testes (more or less globular) is different from that in *S. calappae* and *S. verrucosa*, both of which have testes of a more or less elongate form (*cf.* Boschma, 1931 *c*).

SACCULINA PLANA, sp. n.

Material examined:

Takao, South Formosa, 12 specimens on 8 specimens of *Grapsus strigosus* (Herbst) (4 crabs with 2 parasites each).

Diagnosis of the species.—Male genital organs in the posterior part of the body, outside the visceral mass. One testis only, with two vasa deferentia, the

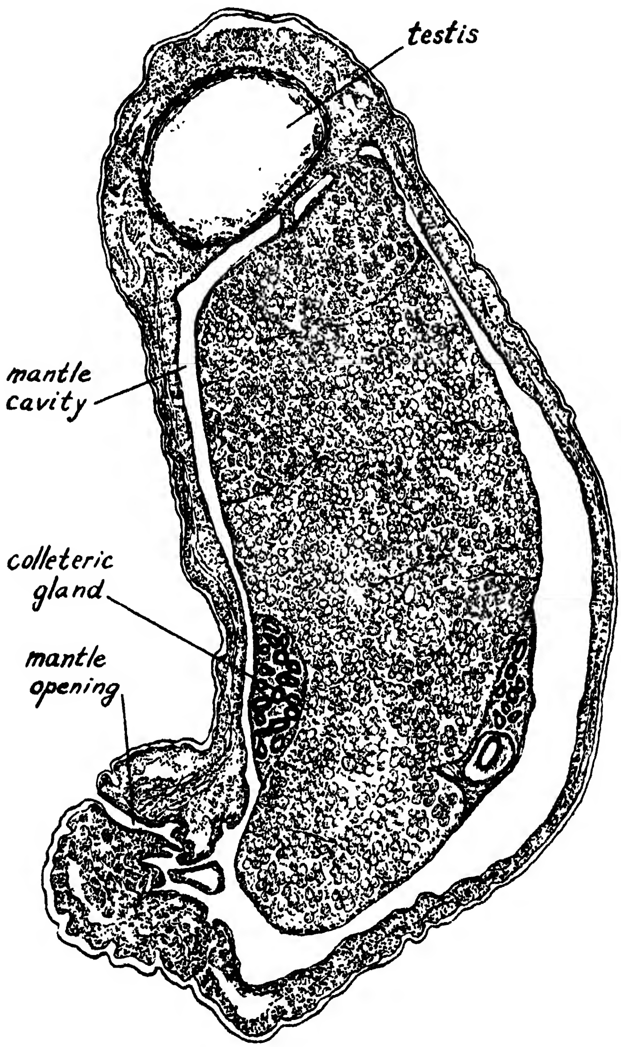

Fig. 36.—*Sacculina plana*. Longitudinal section through the mantle opening. × 26.

testis more or less globular. Colleteric glands more or less hemispherical, with a fairly large number of tubes. External cuticle almost smooth, without

distinct areas. Retinacula with a single spindle, which has a length of approximately 18 μ.

Although the shape of the parasites is somewhat variable they agree in being remarkably flat and broad (fig. 7 *i*). The measurements of one specimen are: breadth 16, height 8·5, and thickness 3 mm.; in another specimen the corresponding measurements are 12·5, 7·5, and 2 mm. respectively. Most specimens are smaller than those referred to above, and some of them are even broader in comparison to their height, so that the height may be less than one-third of the breadth. Generally the smaller specimens have a more or less oval shape; in one of them, e.g., the dimensions are: breadth 4, height 3, and thickness 1·5 mm. In the smaller specimens the surface of the mantle is usually quite smooth; in the larger specimens there are a few grooves or wrinkles

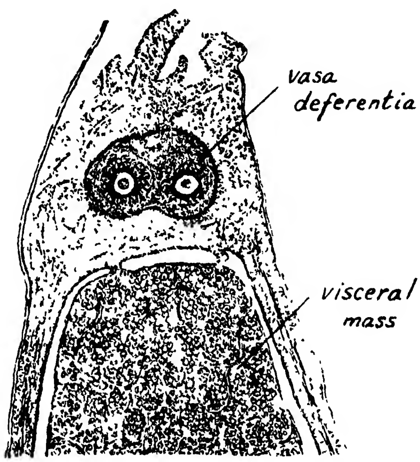

Fig. 37.—*Sacculina plana.* Posterior part of a longitudinal section of the same specimen as that of fig. 36, farther towards the ventral region. ×26.

Generally there is a groove on the abdominal surface caused by the pressure of the ridge marking the position of the gut of the host. The mantle opening lies at the extremity of a very short tube (in some specimens this tube is not developed) at the anterior end of the thoracal surface.

Longitudinal sections have been made of three specimens, all of which show the same particulars, so that the characters of these specimens may be regarded as specific.

The male genital organs are found in the muscular mass to which the stalk is attached, outside the visceral mass. The two testes have completely fused into a common pouch (figs. 36 & 38), the two vasa deferentia are separate. In one of the specimens the dorsal region of the two vasa deferentia is surrounded by a common muscular layer (fig. 37). Different sections of the male genital organs of the specimen from which a section has been represented in fig. 38

are given in fig. 39. In this figure *a* shows the ventral part of the male genital organs, the two vasa deferentia. In *b* one of the vasa deferentia is passing into the testis; the left side of this figure shows a superficial section of the testis, the opening is the lumen of the vas deferens. In section *c* the testis already has a wide lumen, in *d* and *e* the vas deferens of the other side is seen passing

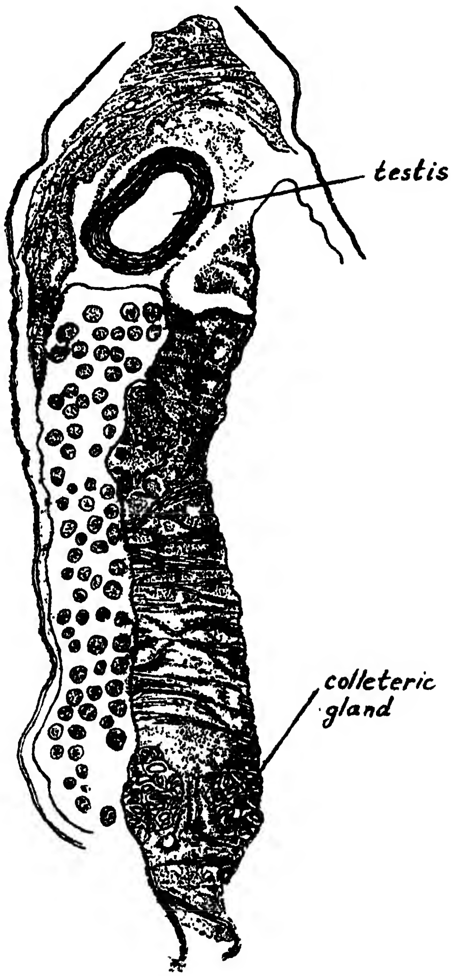

Fig. 38.—*Sacculina plana.* Longitudinal section of another specimen (the greater part of the mantle omitted). × 18.

into the testis. Figures *f* and *g* represent sections of the dorsal part of the testis.

In the specimen from which the sections represented in figs. 38 and 39 have been made the testis has a rather thick wall, in another specimen (fig. 36) it forms a wide sack with a comparatively thin wall. In the third specimen

from which sections have been made (of which no figures are given here) the testis has a thick wall and a narrow lumen.

The colleteric glands (figs. 36 & 38) are found in the posterior part of the visceral mass. They are of medium size and do not contain a very large number of branched tubes.

In one of the sectioned specimens the visceral mass is very thin, as the eggs for the greater part have recently left the ovary, the mantle cavity containing many eggs. In the other specimen the visceral mass contains large quantities of eggs, whilst the mantle cavity is empty. The musculature of the mantle is not so very strongly developed (with the exception of the sphincter of the mantle opening and the musculature in the posterior part of the body). In the visceral mass some transverse muscles are visible, especially in the specimen in which the visceral mass contains only a few eggs (fig. 38).

When strongly enlarged the external cuticle of the mantle usually shows some grooves and other irregularities, but there are no excrescences. The surface is not divided into small areas with irregular contour, as in many other species with a smooth cuticle. Sometimes the cuticle has a dotted appearance, caused by numerous microscopic pits (fig. 40, *a*).

On the internal cuticle of the mantle numerous retinacula are found, which are more or less evenly distributed (fig. 40, *b*, *c*). They consist of a single spindle, on which no barbs could be detected. The spindles on an average have a length of 18 μ.

Besides *Sacculina plana* there are a number of other species of the genus which have the following characters in common: Male genital organs in the posterior part of the body, outside the visceral mass; external cuticle without distinct excrescences. The differences between these species are shown in the following key:—

Height of the body (distance between mantle opening and stalk) much longer than the breadth (distance between dorsal and ventral surface). External cuticle rough, with small grooves and fissures .... *anceps*.

Height of the body smaller than the breadth.

- Testes more or less globular.
  - Only one of the testes well developed or testes completely united.
    - One of the testes rudimentary, but separated from the other. Surface of the cuticle with small areas of 12–16 μ in diameter......... *pustulata*.
    - One testis present, with two vasa deferentia. Cuticle almost smooth, without definite structure at the surface. Retinacula with a single spindle .... *plana*.
  - Both testes well developed.
    - External cuticle consisting of prismatic columns with a central hyaline part.. *sulcata*.
    - Structure of the external cuticle more or less homogeneous, its surface somewhat rough .... *rugosa*.
- Testes more or less cylindrical.
  - External cuticle with small areas approximately 10 μ in diameter, or rough (or covered with small globular excrescences). Colleteric glands with a large number of tubes......................... *flexuosa*.
  - External cuticle rough or covered with irregular excrescences of 6 μ length. Colleteric glands with a small number of tubes......... *bicuspidata*.

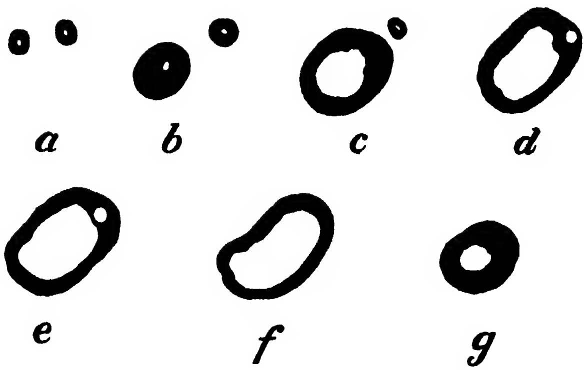

Fig. 39.—*Sacculina plana.* Transverse sections through the male genital organs in different regions of the body of the specimen of fig. 38. *a*, the vasa deferentia; *g*, the dorsal extremity of the testes. × 18.

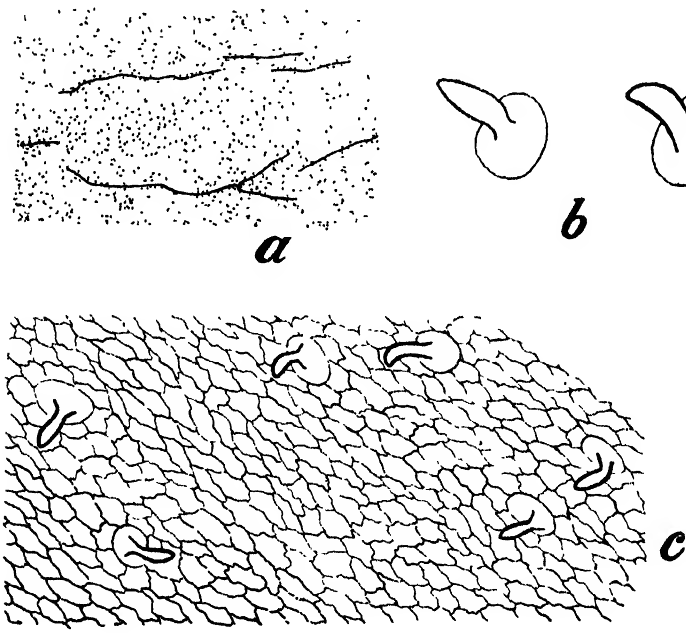

Fig. 40.—*Sacculina plana.* *a*, surface of the external cuticle; *b*, two retinacula; *c*, a number of retinacula on the internal cuticle of the mantle. *a* and *b*, × 530; *c*, × 290.

Sacculina flexuosa, described by Kossmann (1872), is one of the species dealt with in the present paper ; *S. sulcata* and *S. rugosa* have been described by Van Kampen and Boschma (1925). *Sacculina pustulata* has been described by the author in a previous paper (Boschma, 1925), *S. anceps* and *S. bicuspidata* in another (Boschma, 1931 *a*).

SACCULINA FLEXUOSA Kossmann.

Sacculina flexuosa : Kossmann (1872), Van Kampen and Boschma (1925), Boschma (1928 *b*, 1931 *a*, *c*).

Material examined :

Amboina, Edw. Gerrard Jr., 1 specimen on *Grapsus maculatus* (Catesby).

The only specimen in the collection has a breadth of 19 mm., a height of 10 mm., and a thickness of 8·5 mm., this thickness being caused by the enormous quantities of eggs contained in the mantle cavity. Both surfaces of the mantle possess a few irregular grooves, the largest of which is found at the median region of the surface which was turned towards the abdomen of the crab. The peripheral parts of the mantle, especially the posterior parts of the dorsal and ventral region, show a great number of small warts, giving a more or less rough appearance to those parts of the mantle. The mantle opening has the shape of a narrow slit ; it lies at the extremity of a short thick-walled tube, which is flattened in lateral direction. The distance between the mantle opening and the place of insertion of the stalk is somewhat shorter than the largest height.

Longitudinal sections have been made from the visceral mass and the region of the mantle adjoining the stalk. The most curious particular of this specimen is that, as in Kossman's type-specimen, the visceral mass is strongly curved in a lateral direction (fig. 41), so that two folds are present, one at the anterior part and another in the posterior region. The name *flexuosa* is derived from this character, which, however, does not occur in all the specimens. It seems, on the contrary, to occur very rarely in the species.

The male genital organs are present in the muscular posterior region of the body, from which the stalk takes its origin. The testes, which are rather large and comparatively long, are completely separated. In their ventral part they gradually pass into the vasa deferentia, which are large, but with a narrow lumen. This is caused by numerous ridges and lamellae protruding inwardly from the wall of the vas deferens (fig. 41). The dorsal extremity of the testes is slightly curved, so that in sections of the extreme dorsal part the lumen of the testes is twice visible.

The colleteric glands are large and contain numerous branched tubes. In the figure sections of the ventral part of the colleteric glands are represented ; towards the median plane these glands are much more voluminous. The colleteric glands lie in the anterior half of the visceral mass.

The mesentery of the specimen is longer than is usual in *Sacculina* ; it is complete in the dorsal half of the body, and, moreover, it is found for a short

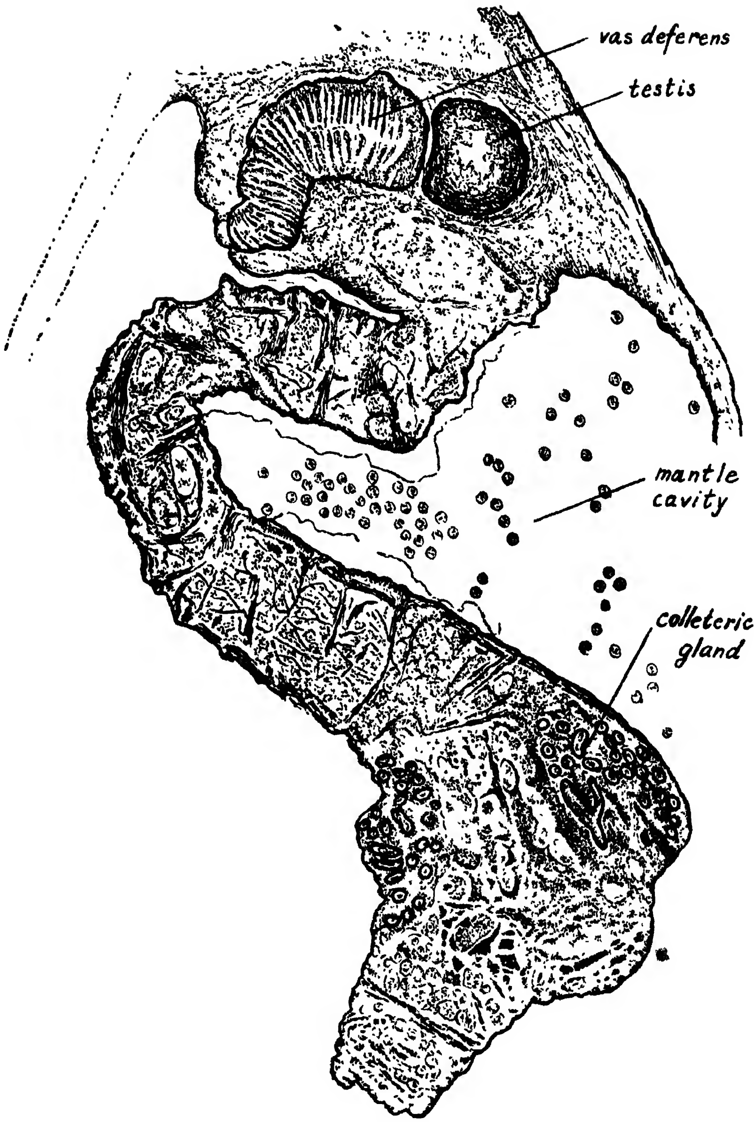

Fig. 41.—*Sacculina flexuosa*. Longitudinal section (the greater part of the mantle omitted). × 18.

distance in the ventral half, uniting the visceral mass with the mantle. Kossmann (1872) remarks that the same feature occurred in the type-specimen of the species.

In the visceral mass some muscles are to be seen, especially in transverse direction. The mantle is strongly muscular. The mantle cavity was filled with an enormous quantity of eggs, which caused the swollen appearance of the animal.

With the exception of the small tubercles referred to above the mantle is smooth. In some parts the surface is somewhat wrinkled, and in these parts minute stripes are visible. Excrescences do not occur. The external cuticle of the mantle has a thickness of about 50 μ in the posterior part of the body, in the anterior region it is thicker.

On the thin internal cuticle of the mantle there are numerous retinacula, which are more or less regularly distributed (fig. 42). Each retinaculum

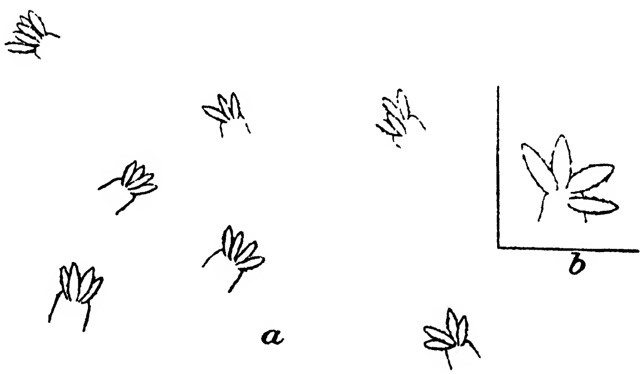

Fig. 42.—*Sacculina flexuosa*. Retinacula as they are distributed on the surface of the internal cuticle, $\times 290$. At the right one retinaculum, $\times 530$.

consists of a basal part and three to five spindles. The latter have a length of approximately 13 μ and they bear distinct barbs.

In Kossmann's description (1872) of *Sacculina flexuosa* the following points are especially mentioned: the mesentery is longer than is usual in *Sacculina*, as it is found also in the ventral half of the body; the visceral mass is folded in a lateral direction; the external cuticle of the mantle has a thickness of 50–70 μ and is slightly wrinkled. All these characters are found also in the specimen in the British Museum. There is, however, one particular mentioned by Kossmann, which does not hold good for the specimen dealt with here, viz. the shape of the male genital organs. According to Kossmann the testes are retort-shaped, whilst the vasa deferentia have the shape of a horseshoe, the opening of which is turned towards the stalk. From Kossmann's figure one would get the impression that the vasa deferentia run in a dorsal

direction, the closed extremities of the testes being turned towards the ventral surface. In all probability Kossmann has made an error here. Perhaps the thick part of the male genital organs in his figure represents the vas deferens, which in this species has approximately the same thickness as the greater part of the testes. The curved part of the male genital organs then represents the closed extremity of the testis, which is also slightly curved in the British Museum specimen.

Kossmann's specimen was a parasite of *Grapsus strigosus* (Herbst) (=*Grapsus grapsus*), and the specimen obtained by the 'Siboga' expedition (Van Kampen and Boschma, 1925) was a parasite of the same host. The host of the specimen in the British Museum is given as *Grapsus maculatus*, a name which is synonymous with *G. grapsus*. Besides these two hosts the following crabs are known to be infested by *Sacculina flexuosa*: *Varuna litterata*, *Macrophthalmus erato*, *Plagusia depressa*, and the variety *immaculata* of the latter (*cf.* Boschma, 1928 *b*, 1931).

Genus Ptychascus, nov.

Diagnosis of the genus.—Body laterally compressed, as in *Sacculina*. Mesentery thin, complete (extending from the stalk to the mantle opening). Inner surface of the mantle with a great number of septa which extend into the mantle cavity. Testes straight, in the posterior part of the body (as in *Sacculina*). Male genital openings in the ventral half of the mantle cavity. Colleteric glands with a number of branched tubes, approximately in the central part of the lateral surfaces of the visceral mass. Larva hatching in cypris stage.

The genus differs from *Sacculina* by the possession of the septa on the inner surface of the mantle, but corresponds closely with it in all other respects. In the only known species the mantle opening is found at the extremity of a long tube; it is not certain that this character will occur in other species of the genus (if such are discovered), so that for the present I prefer to regard it as a peculiarity of the species.

Ptychascus glaber, sp. n.

Material examined:

Marajo Island, Amazon River, 1923, 2 specimens on *Sesarma (Holometopus) benedicti* Rathbun, 4 specimens on *Aratus pisonii* (Milne-Edwards) (2 on one host).

Diagnosis of the species.—Male genital organs in the posterior part of the body, outside the visceral mass. Testes more or less cylindrical, completely separated. Mantle opening at the extremity of a long tube, which is bent towards the dorsal surface. External cuticle of the mantle smooth, with distinct areas (diameter from 10 to 20 μ) of an irregular shape.

The specimens have a more or less oval shape, in some of them the median part of the dorsal and ventral region is somewhat pointed (fig. 43, *a*), in others the posterior part of the dorsal and ventral regions is more or less angular (fig. 43, *b*). The dimensions of one specimen on *Sesarma benedicti* are: breadth 7,

height 3·5, and thickness 2 mm., the other specimen is a little smaller. The largest specimen on *Aratus pisonii* has the following dimensions: breadth 12, height 7, and thickness 3·5 mm.; in the smallest specimen (one of the two on the same host, *cf.* Pl. **7**, fig. 44) the dimensions are: breadth 7, height 4, and thickness 2 mm. The lateral surfaces of the animals are comparatively flat. The mantle is smooth with the exception of a few irregular grooves and wrinkles and a median groove at the surface which was turned towards the abdomen of the crab. This groove does not occur in the two specimens which lived together on the same crab, so that in the other specimens this groove is caused by the pressure of the ridge marking the position of the gut of the host.

Usually the mantle is comparatively thick, but in one specimen it is much thinner and more or less transparent, so that the place of insertion of the septa is dimly visible (fig. 43, *a*). The stalk may be surrounded by an area of the

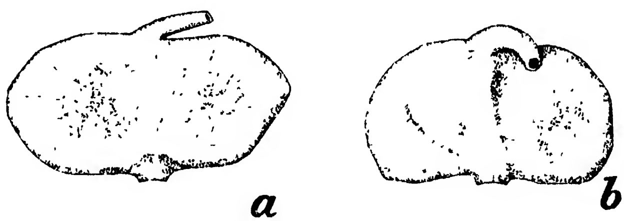

Fig. 43.—*Ptychascus glaber*, the specimens from which sections have been made. *a*, specimen on *Sesarma benedicti*; *b*, specimen on *Aratus pisonii*. The figure shows the surface which was turned towards the thorax of the hosts; the stalk is found at the lower part, the mantle opening at the upper part of the figures. *a*, ×5·25; *b*, ×3·75.

mantle with a thicker layer of chitin (fig. 43, *a*), but in most specimens this area is not pronounced.

In the anterior region the mantle is protruded into a long narrow tube, at the extremity of which the mantle opening is found. Curiously enough, this tube in all the specimens is directed towards the dorsal surface of the animal. The tube may reach a length of 2 mm. (in the largest specimen) and it is straight or somewhat curved (fig. 43 & Pl. **7**, fig. 44).

From one of the specimens on *Sesarma benedicti* and from one of the specimens on *Aratus pisonii* series of longitudinal sections have been made. As the particulars of the two specimens correspond in every important detail, the description given here applies to both of them, unless special differences are mentioned.

With the exception of the septa on the inner surface of the mantle the anatomy of the specimens corresponds closely with that of *Sacculina*: the mesentery runs from the stalk to the tube at the extremity of which the mantle opening is found, and the testes are straight organs lying before the stalk.

The male genital organs are found in the posterior part of the body, outside the visceral mass (fig. 45). The testes are of fairly large size; towards the ventral part of the body they gradually pass into the vasa deferentia, which in the specimen on *Sesarma* form narrow tubes; in that on *Aratus* the wall of these canals is thicker. The testes remain completely separated for the whole of their extent.

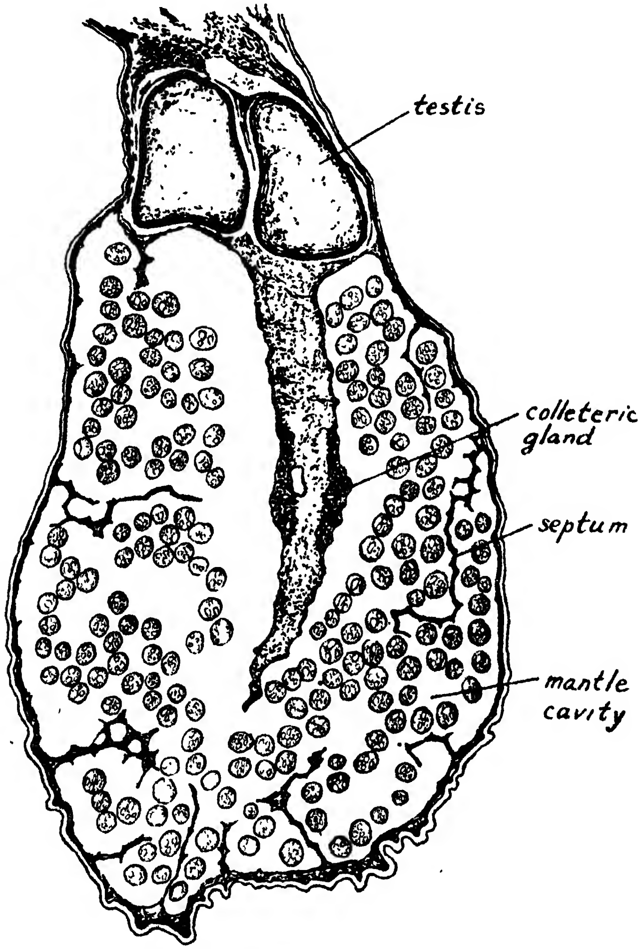

Fig. 45.—*Ptychascus glaber.* Longitudinal section of a specimen from *Sesarma benedicti.* × 36.

The colleteric glands are found in the neighbourhood of the central part of the lateral surfaces of the visceral mass, somewhat nearer to the anterior region than to the posterior part (fig. 45). They contain a fairly large number of narrow branched tubes; in the specimen on *Aratus* more than in that on *Sesarma*,

The mantle is not strongly muscular except in the region where the tube of the mantle opening is connected with the mantle. This tube itself contains a well-developed muscular layer; its lumen is very narrow. In the visceral mass there are a few transverse muscles, and the posterior part of the body to which the stalk is attached contains some strong muscles.

The septa do not occur in large numbers. Between each pair of septa numerous eggs are found in both specimens. In the specimen on *Aratus* from which sections have been made the mantle cavity is so crowdedly packed with eggs that the septa are not easily visible, in that on *Sesarma* the septa are more distinctly visible, as there are fewer eggs present in the mantle cavity. The septa form thin lamellae which protrude with their free extremities between the eggs in the mantle cavity, dividing the mantle cavity into a small number of chambers which are most distinctly visible in sections through the extreme dorsal or ventral part of the animal (fig. 46). Probably the septa of *Ptychascus*

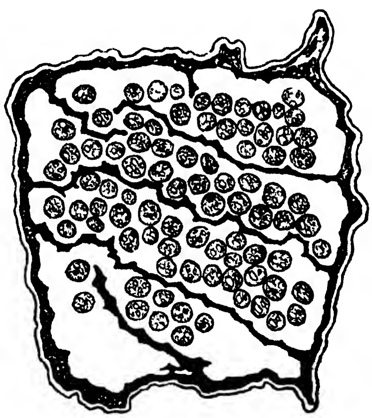

Fig. 46.—*Ptychascus glaber*, same specimen as that of fig. 45. Longitudinal section through the pointed dorsal part, showing the septa. $\times 36$.

have the same function as those of *Septosaccus* (*cf.* Duboscq, 1912), viz. forming separate brood-pouches in the mantle cavity for the developing eggs. It is not certain whether they also have a respiratory function or not.

The structure of the external cuticle of the mantle is similar in all the specimens examined. In the specimens from which sections have been made the external cuticle has a thickness of approximately 12 μ (in the specimen on *Sesarma*) and 20 μ (in the specimen on *Aratus*). Some parts of the external cuticle are more or less wrinkled, but for the greater part this cuticle is altogether smooth. When strongly enlarged the surface is seen to be divided into small irregular areas, which have a diameter varying between 10 and 15 μ (fig. 47). The cuticle does not possess excrescences.

On the internal cuticle of the mantle no retinacula could be found in the preparations made for this purpose.

In one of the specimens on *Aratus pisonii* the mantle cavity contains fully developed cypris larvae (fig. 48). The length of these larvae varies between 175 and 235 μ; they possess a pigmented eye, well-developed antennae, and six pairs of swimming-legs with long bristles, and there are also a few bristles at the extremity of the abdomen.

Besides *Ptychascus glaber* two species of Rhizocephala are known from fresh water, viz. *Sesarmaxenos monticola* Annandale from the Andaman Islands and *S. gedehensis* Feuerborn from West Java. In the description of *S. monticola* by Annandale (1911) two mantle openings are mentioned; probably only one of these is characteristic of the species, the other may have been formed by accident. According to Annandale the visceral mass is apparently attached to the mantle by a mesentery that surrounds the ring of attachment, but he does not mention how far it extends towards the mantle opening. The description is rather imperfect, and probably the only available specimen

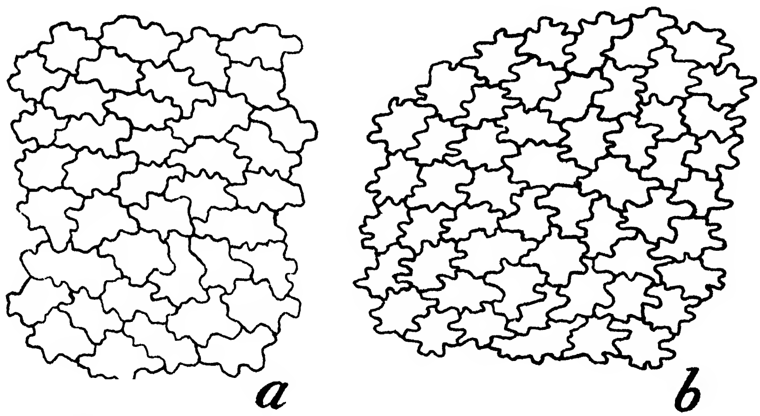

Fig. 47.—*Ptychascus glaber*. *a*, surface of the external cuticle of a specimen on *Sesarma benedicti*; *b*, surface of the cuticle of a specimen on *Aratus pisonii*. $\times$ 530.

was not in a very good state of preservation. It is interesting that the specimen contained cypris larvae in the mantle cavity.

The characters of *Sesarmaxenos gedehensis* have been described in detail by Feuerborn (1932). *S. gedehensis* has a mantle opening which is directed towards the left side of the host (as *S. monticola*); the mesentery is not only, as in *Sacculina*, a kind of ligament connecting the visceral mass with the mantle, but it is excessively developed and forms large folds which extend into the mantle cavity, forming brood-pouches for the developing eggs. The larvae hatch from the egg-membrane in the cypris stage.

In *Ptychascus* the structure of some parts is different from that of *Sesarmaxenos*, but a similar effect is accomplished. Externally the lateral surfaces of the animal are more or less bilaterally symmetrical: the base of the tube of the mantle opening is found approximately at the centre of the anterior

region. The tube itself, however, is directed towards the left side of the host, so that in most cases it projects from under the abdomen of the crab. Probably in fresh water Rhizocephala it is of great value to have the mantle opening not covered by the abdomen of the crab, so that the necessary constant supply of water in the mantle cavity is not prevented by this part of the host. Brood pouches are formed here by the septa on the internal surface of the mantle, and the mesentery does not differ in shape and size from that in *Sacculina*.

In *Ptychascus*, as in *Sesarmaxenos*, the young leaves the egg-membrane in the cypris stage. This affords further protection to the brood, and is probably a result of the freshwater habitat.

In Rhizocephala we consequently see a similar phenomenon to that occurring in many other groups of animals, so far as the protection of the brood is concerned. In the majority of genera the young leave the egg-membrane in the

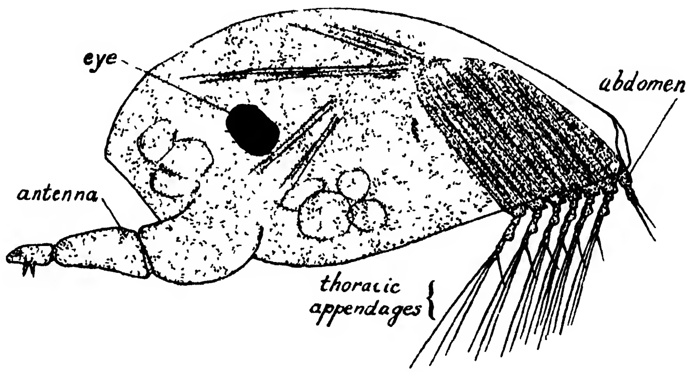

Fig. 48.—*Ptychascus glaber*. Cypris larva. ×290.

nauplius stage. In some, however, as in *Clistosaccus*, *Sylon*, *Sesarmaxenos*, and *Ptychascus*, the young hatch in the cypris stage. The two former genera are typical arctic animals, the two latter occur in fresh water only.

Genus Drepanorchis.

Drepanorchis neglecta (Fraisse).

Sacculina neglecta: Fraisse (1877).
Sacculina phalangi: Norman and Scott (1906).
Drepanorchis neglecta: Boschma (1927 *b*, *c*, 1928 *a*).
For other literature on the species *cf*. Boschma (1927 *b*).

Material examined:

Naples, G. W. Smith, 7 specimens on 6 specimens of *Inachus mauritanicus* Lucas.
Naples, 1887, 1 specimen on *Inachus mauritanicus* Lucas (collection Norman).
Dalmatia, from Heckel collection, 1 specimen on *Macropodia rostrata* (L.).
Plymouth, 1903, 2 specimens on 1 specimen of *Macropodia longirostris* (Fabr.).

The shape of the parasites does not differ from that of other specimens belonging to this species; generally they have a more or less rounded form,

the height not greatly exceeding the breadth. The specimens differ in size; the largest in the collection (on *Inachus mauritanicus*) has a breadth of 13 mm.

It is interesting that two of the specimens are parasites of *Macropodia longirostris*, as the anatomy of specimens from this crab has not previously been studied. From one of these specimens a series of sections has been made. As was to be expected, the anatomy does not differ in any respect from that of the parasites of *Macropodia rostrata* and of the genus *Inachus*: the testes extend in a wide curve through the whole of the visceral mass and the colleteric glands are found in the anterior region of the visceral mass.

Besides the literature on the species given in a previous paper (Boschma, 1927 *c*) the occurrence of this parasite on *Macropodia rostrata* has been mentioned by Norman and Scott (1906), who named the parasite *Sacculina phalangi* Hoek: " On the abdomen of *Stenorhynchus longirostris* at Plymouth, 1903 (A. M. N.). The type-specimen of Hoek was parasitic on *Stenorhynchus rostratus* " (*l. c.*, p. 226). In all probability the specimens from Plymouth in the collection of the British Museum are those collected by Norman.

Genus Loxothylacus.

Loxothylacus aristatus Boschma.

p.p. *Sacculina pilosa*: Van Kampen and Boschma (1925).
Loxothylacus aristatus: Boschma (1931 c).

Material examined:

Macclesfield Bank, H.M.S. 'Egeria', 42–46 fms., 1 specimen on *Lambrus contrarius* (Herbst).

The parasite has a more or less oval shape (fig. 49, *a*); its dimensions are: breadth 18·5, height 14, and thickness 7·5 mm. The mantle opening lies at the extremity of a rather pronounced tube, situated in the centre of the anterior margin. The surface of the mantle is almost smooth to the naked eye, only the marginal parts are somewhat pitted and grooved, and the surface of the parasite which was turned towards the abdomen of the crab shows a deep median groove, caused by pressure of the median ridge of the abdomen. When compared with the type-specimen the difference in shape of the two parasites is rather striking; but as in the Sacculinidae the shape of the parasites of the same species on different hosts often presents great differences, this feature is of little importance. The same holds true for the differences in size: the specimen in the British Museum is more than twice as large as that obtained by the 'Siboga' Expedition.

The internal structure of the parasite was studied by means of a series of longitudinal sections. The male genital organs are embedded in the posterior part of the visceral mass. The testes are distinctly curved, but the curved part of each testis does not extend noticeably in a ventral direction and is chiefly directed anteriorly (fig. 50). The closed parts of the testes form rather wide pouches, with a thin wall which gradually becomes thicker towards the

posterior part of these organs (the region in the vicinity of the mesentery). The thick-walled part of the two testes runs along the mesentery and gradually passes into the vas deferens. The vasa deferentia communicate with the mantle cavity in the ventral half of the animal. The male genital organs remain separated for the whole of their extent.

The colleteric glands are found at each side of the visceral mass, not far from the central part, but somewhat nearer to the anterior than to the posterior extremity (fig. 50). These glands contain a large number of narrow branched tubes.

The musculature of the visceral mass, of the region of the stalk, and of the mantle is well developed. The mantle cavity contains a large quantity of eggs.

The external cuticle of the mantle is comparatively thick (on an average 80 μ); its surface is covered with excrescences which differ in structure from that of the main layers. Whilst the main layers of the cuticle are easily stained, the excrescences keep their transparent appearance also in stained sections.

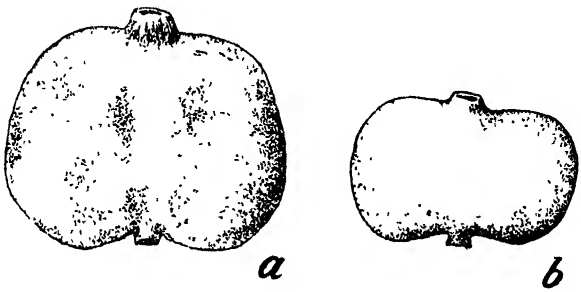

Fig. 49.—a, *Loxothylacus aristatus*; b, *Loxothylacus spinulosus*. The surface of the animals which was turned towards the thorax of their hosts is represented; the mantle opening is found in the upper part, the stalk in the lower part of the figure. *a*, $\times 2$; *b*, $\times 7{\cdot}2$.

Each of these excrescences consists of a small number of rigid spines, which are united proximally in a common base (fig. 51). In the greater part of the mantle these excrescences have a length of 45 μ; in some regions they are slightly larger and in others smaller.

On the thin internal cuticle of the mantle no retinacula could be found.

The specimen dealt with here differs in some respects from the type-specimen of *Loxothylacus aristatus* (*cf.* Boschma, 1931 *c*). In the latter the testes are not enlarged into a voluminous pouch with a thin wall; but this difference between the two specimens may be due to the fact that the two are of different sizes and therefore the one may be much younger than the other. Moreover, the excrescences of the external cuticle do not correspond in every detail in the two specimens. In the type-specimen the excrescences are larger than those of the specimen dealt with here, and they are composed of a larger number of spines. These differences, however, are of minor importance, for in many

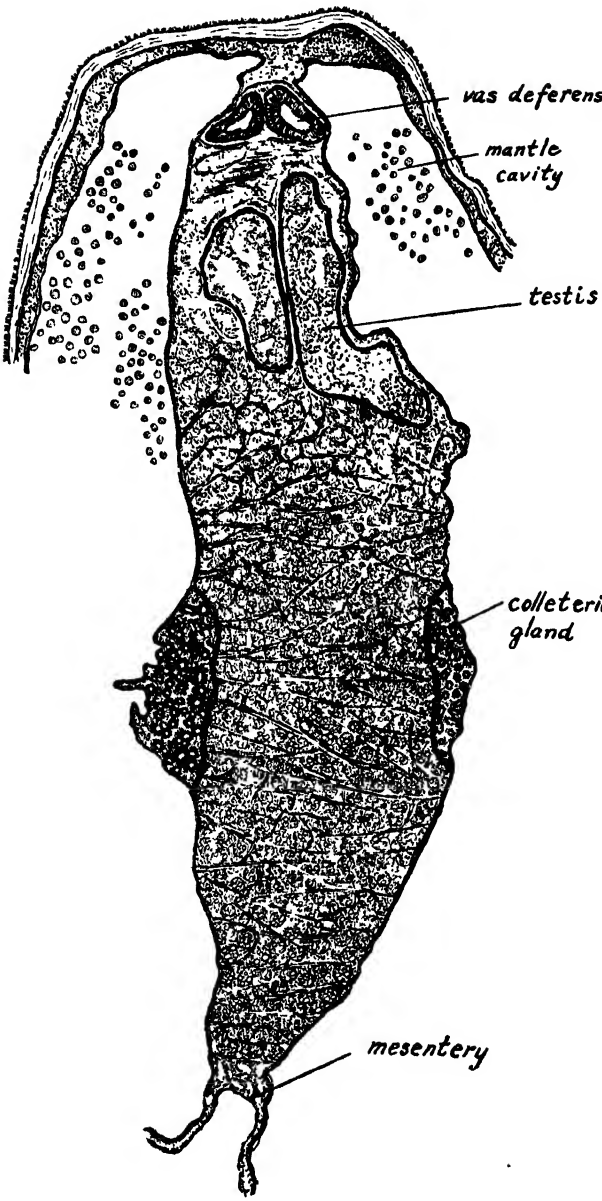

Fig. 50.—*Loxothylacus aristatus.* Longitudinal section (the greater part of the mantle omitted). × 15.

species of Sacculinidae with excrescences of this kind the number of spines which are united on a common basal part varies in the different parts of the mantle. In the vicinity of the stalk the excrescences usually are less fully developed than on other parts of the mantle.

Loxothylacus desmothrix and *L. setaceus* (*cf.* Boschma, 1931 *c*) have excrescences of approximately the same type as those of *L. aristatus*. In *L. setaceus* one of the testes is rudimentary, whilst in *L. aristatus* both testes have approximately the same size. *L. desmothrix* differs from the two other species by the peculiar structure of its excrescences: the spines of each excrescence are united into a number of thick branches, the latter are fused with the common basal part.

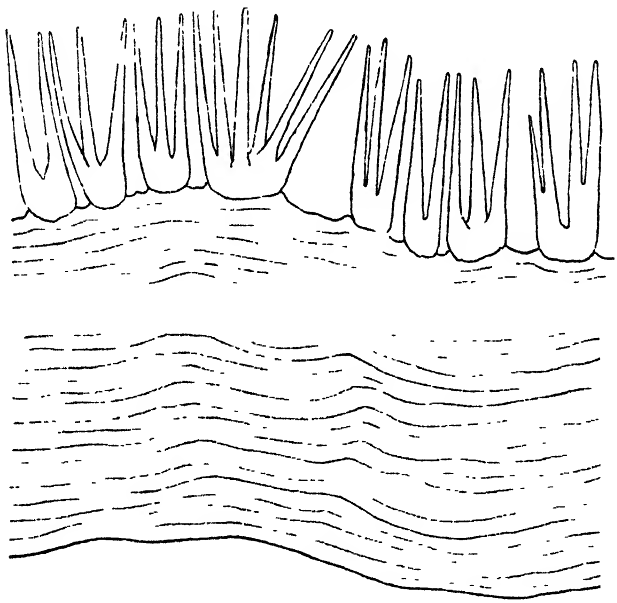

Fig. 51.—*Loxothylacus aristatus*. Section of the external cuticle. × 530.

LOXOTHYLACUS SPINULOSUS Boschma.

Loxothylacus spinulosus: Boschma, 1928 *b*.

Material examined:

Hongkong, Barney coll., 2 specimens on two young specimens of *Pilumnus seminudus*.

The following is an amended diagnosis of the species, based on the specimens in the British Museum and on that in the Leiden Museum (*cf.* Boschma, 1928 *b*): Male genital organs rather strongly curved, in the posterior half of the visceral mass. One of the testes larger than the other. Colleteric glands with a fairly large number of tubes. Surface of the external cuticle of the mantle divided

into small areas with an irregular shape (diameter of these areas varying between 6 and 18 μ). The surface of the cuticle covered with small blunt excrescences, which have a length of 4–6 μ. Retinacula with one or two barbed spindles of approximately 13 μ length.

The two specimens from Hongkong have approximately the same size ; the dimensions of one of them are : breadth 4, height 2·5, and thickness 1·5 mm. ; in the other specimen the corresponding dimensions are : 4, 2·25, and 1 mm. respectively. One of the specimens has the dorsal and ventral region neatly rounded (fig. 49, *b*) ; in the other specimen these parts are protruded into small points, so that the animal has an angular shape. In both specimens the surface of the mantle is smooth and there is a short concavity near the stalk on the surface which was turned towards the abdomen of their hosts. The mantle opening lies at the extremity of a very short tube in the central part of the anterior region.

From the specimen represented in fig. 49, *b*, a series of longitudinal sections has been made. The visceral mass is attached to the mantle at some distance from the stalk, the mesentery is complete, and the testes are curved, so that the specimen undoubtedly belongs to the genus *Loxothylacus*.

One of the testes (that of the right side) is much larger than the other. Its closed part forms a comparatively wide sac, whilst the corresponding part of the other testis is not noticeably enlarged (fig. 52). The curve of the testis is rather narrow, so that in longitudinal sections the testes are seen lying just before the vasa deferentia. The latter are narrow canals, which run along the mesentery, and the male genital openings are found in the ventral half of the body.

In comparison to the size of the body the colleteric glands are of good size (fig. 52). They contain a number of branched tubes. The glands lie approximately in the centre of the lateral surfaces of the visceral mass, somewhat nearer to the anterior than to the posterior region.

The animal is not strongly muscular. With the exception of the region of the stalk and the sphincter of the mantle opening there is a thin muscular layer beneath the external cuticle. The visceral mass contains hardly any muscles. In comparison to the size of the whole animal the visceral mass is extremely small. The mantle cavity is wide and more or less inflated, but contains only a few eggs.

In the specimen from which sections have been made the external cuticle of the mantle has a thickness of 15–25 μ. In both specimens the surface of this cuticle shows, at least in many parts, neat little areas which have an irregular shape (fig. 53, *a*). In the centre of each area the cuticle may bear a small, more or less blunt excrescence (fig. 53, *c*). When the surface of the cuticle is examined these excrescences often are little distinct ; in sections, however, they are clearly visible. The excrescences of the cuticle may reach a height of 6 μ.

On the internal cuticle of the mantle retinacula occur which consist of a basal

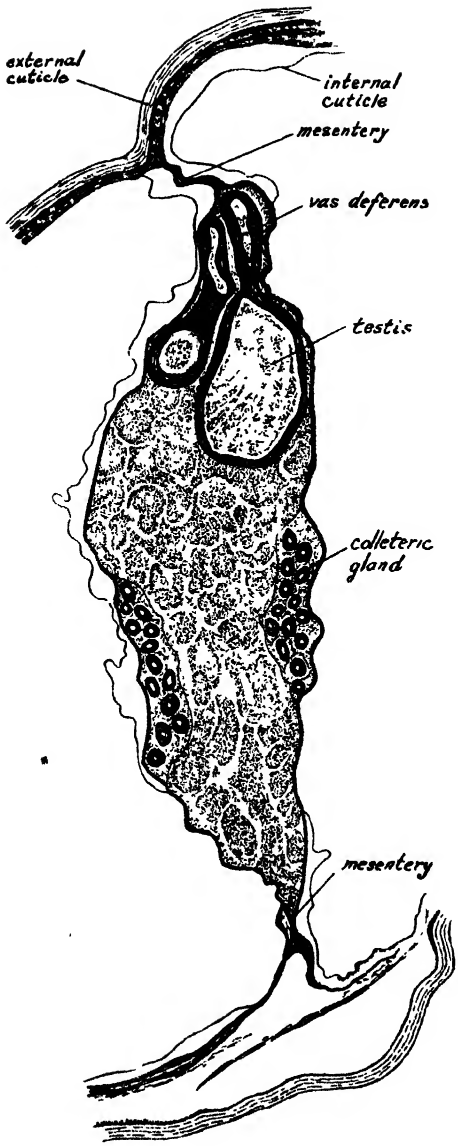

Fig. 52.—*Loxothylacus spinulosus*. Longitudinal section (the greater part of the mantle omitted). ×72.

part and one or two spindles (fig. 53, *b*). The latter have a length of approximately 13 μ ; their barbs are distinctly visible.

It is not altogether certain that the specimens from Hongkong belong to the same species as the specimen from the Pacific Ocean (*cf.* Boschma, 1928 *b*). There are some differences, but they are not striking enough to justify specific separation. In the first place, there is a difference in the shape of the testes. In the specimen in the Leiden Museum one of the testes is larger than the other, just as in the specimen in the British Museum, but in the former the curve of the testes is much wider than that in the latter specimen. The colleteric glands of the Leiden specimen are larger than those of that in the British Museum and contain a larger number of branched tubes. These differences, however, may be due to the fact that the visceral mass of the British Museum specimen is much smaller than that of the other.

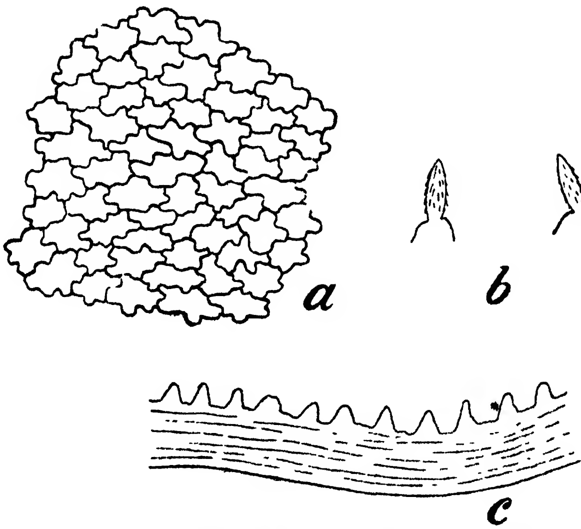

Fig. 53.—*Loxothylacus spinulosus*. *a*, surface of the external cuticle ; *b*, retinacula ; *c*, section of the external cuticle. × 530.

The excrescences of the external cuticle also show some differences, but these again are of minor importance. They are shorter and slenderer in the specimen in the Leiden Museum.

Loxothylacus spinulosus can easily be distinguished from all other species of the genus, as all these other species have excrescences of larger size.

Genus Parthenopea.

After having studied the anatomy of *Parthenopea subterranea* (*cf.* Boschma, 1927 *c*) I came to the same conclusion as Kossmann (1873), viz. that it does not differ in any important detail from the genus *Lernaeodiscus*. The most

striking difference between the two genera, in my opinion, was the pronounced bilateral symmetry of *Parthenopea* in contradistinction to the asymmetrical species of *Lernaeodiscus*. Since then I have demonstrated that *Lernaeodiscus porcellanae* Müll. has a neatly bilaterally symmetrical structure (*cf.* Boschma, 1931 *a* ; also the description and figures of the species by Müller, 1862, already give evidence of this symmetry), so that the differences between *Parthenopea* and *Lernaeodiscus* are still less significant. There remains, however, the fact that the orientation of the parasites in regard to their hosts is different in the two genera : in *Parthenopea* the dorsal surface of the parasite is directed towards the left side of the host, whilst in *Lernaeodiscus* it is directed towards the abdomen of the host.

PARTHENOPEA SUBTERRANEA Kossmann.

Parthenopea subterranea : Kossmann (1873), Boschma (1927 *c*), Popov (1929).

Material examined :

Naples, G. W. Smith, 1 specimen on *Callianassa stebbingi* Borrad.

Naples, 1887, 1 specimen on *Callianassa stebbingi* Borrad. (collection Norman).

Zoological Station, Naples, 3 specimens on *Callianassa stebbingi* Borrad. (collection Norman).

The specimens in the collection of the British Museum do not differ in any important detail from other specimens of the species.

Until recently *Parthenopea subterranea* was known only from Naples ; Popov (1929) records the species from the Bay of Sebastopol (Black Sea).

Genus LERNAEODISCUS.

LERNAEODISCUS MUNIDAE (Smith).

Triangulus munidae : Smith (1906).

Lernaeodiscus munidae : Boschma (1928 *a*, *b*).

For other literature on the species *cf.* Boschma (1928 *a*).

The specimen does not differ in any important detail from those dealt with in the papers cited above. Its mantle is smooth and does not possess marginal lappets.

LERNAEODISCUS GALATHEAE (Norman & Scott).

Sacculina galatheae : Norman & Scott (1906).

Lernaeodiscus galatheae : Pérez (1908), Boschma (1927 *c*, 1928 *a*).

For other literature on the species *cf.* Boschma (1928 *a*).

Material examined :

Plymouth, 1889, 1 specimen on *Galathea intermedia* Lillj. (collection Norman, labelled : *Sacculina galatheae* Norman, type).

Firth of Forth, Henderson, 1885, 1 specimen on *Galathea nexa* Embleton (collection Norman, labelled : *Sacculina galatheae*, sp. n.).

Naples, G. W. Smith, 1 specimen on *Galathea nexa* Embleton.

Norman and Scott (1906) published the following notes on this species : '*Sacculina galatheae*, sp. n. We give this name to a little form found on the abdomen of *Galathea intermedia*, taken off Plymouth in 1889. There is little

or no character in the species of this genus; but it can hardly be supposed that the very small form found upon *G. intermedia* can be the same as that which is common on *Carcinus maenas*' (*l. c.*, p. 226). The copy of the cited book in the British Museum (Natural History) has been there since April 1906, and, as the mongraph on the Rhizocephala by Smith (1906) had not appeared before August of that year, it is evident that the species should be named *Lernaeodiscus galatheae* (Norman & Scott).

The type-specimen has a breadth of nearly 5 mm.; the specimens on *Galathea nexa* have a breadth of nearly 6 and 4 mm. respectively. In the type-specimen and in the smallest specimen there are no marginal lappets on the mantle; in the largest specimen these lappets are slightly developed. The mantle opening is turned more or less towards the right side of the host.

According to Smith (1906) *Lernaeodiscus galatheae* occurs at Naples as a parasite of *Galathea intermedia* and *G. dispersa* (=*G. nexa*). In a previous paper (Boschma, 1928 *a*) I described the anatomy of specimens on *Galathea intermedia*. The anatomy of the parasite on *Galathea nexa* being hitherto unknown, sections have been made of the specimen from the Firth of Forth. The anatomy of this specimen does not differ in any respect from that of the parasites of *G. intermedia*; colleteric glands and testes have the same shape and structure, so that this parasite undoubtedly belongs to the same species.

Genus Sylon.

Sylon hippolytes M. Sars.

Sylon hippolytes: Sars (1870), Boschma (1928 *a*, 1931 *a*).
For other literature on the species *cf.* Boschma (1928 *a*).

Material examined:

Greenland, 'Valorous' Expedition, 3 specimens on *Spirontocaris ? polaris* (Sab.) (2 on one host, collection Norman).
Tromsö, Schneider coll., 1889, 3 specimens on *Spirontocaris ? pusiola* (Kröyer) (collection Norman).
Shetland, 1865, 4 specimens on *Pandalina brevirostris* (Rathke) (collection Norman).
Norway, 1878, 1 specimen on *Pandalina brevirostris* (Rathke) (collection Norman).
Greenland, 'Valorous' Expedition, 1875, 2 specimens on *Spirontocaris spinus* (Sowerby).

In a previous paper (Boschma, 1928 *a*) the results are given of a detailed study of the anatomy of the specimens of the genus *Sylon* living on different hosts. I concluded that there are no characters for establishing different species among the known specimens, and in consequence I consider them all to be representatives of *Sylon hippolytes*.

All the specimens in the collection have been preserved for more than forty years, so I could not expect to find any more details in their anatomy than those laid down in my previous paper. Two specimens of *Sylon* on *Pandalina brevirostris* have been cut into sections to ascertain whether their anatomy is in accordance with that of specimens from other hosts. The

structure of specimens on *Spirontocaris polaris*, *S. pusiola*, and *S. spinus* has been studied before (Boschma, 1928 *a*), so that no more sections have been made of the specimens on these prawns. In the sections of the specimens on *Pandalina brevirostris* I have not found any differences from those on other hosts and I am thus convinced that they do not belong to a distinct species. One of the parasites of *Pandalina brevirostris* is an old specimen, strongly shrivelled (length 8 mm., breadth and thickness 2 to 2·5 mm.); the other sectioned specimen from the same host is a very young parasite which had recently penetrated through the cuticle of its host.

Genus Thompsonia.

The following diagnosis of the genus is quoted from Potts (1915, pp. 28, 29): 'A colonial Rhizocephalan infecting various Decapod Crustacea. Root system diffuse, widely distributed in body of host, sending branches into thoracic and abdominal appendages, which give off numerous sacs containing reproductive cells and becoming external at a moult of the host. These *external sacs* consist of a mantle and visceral mass without an intervening mantle cavity; mantle thin and devoid of muscle fibres. Visceral mass contains ovary only without generative ducts, testis, or nerve ganglion. Development probably parthenogenetic. Nauplius stage omitted from life-history, larvae liberated at Cypris stage, after disintegration of the visceral mass, through apical cloacal aperture which appears in the mantle at a late stage. Moulting of host not prevented.'

The different species and the unnamed specimens of the genus mentioned in literature are given in the following list :—

Name.	Host.	Locality.	Author.
Thompsonia globosa	*Melia tessellata.*	Philippine Islands.	Kossmann, 1872.
Thompsonia sinensis ...	?	China ?	Keppen, 1877.
......	*Betaeus malleodigitus.*	Fiji Islands.	Bate, 1888.
Thylacoplethus haddoni .	*Alpheus avarus.*	Torres Strait.	Coutière, 1902 *b*.
Thylacoplethus edwardsi.	*Alpheus edwardsi.*	Thursday Island.	Coutière, 1902 *b*.
Thylacoplethus heurteli..	*Alpheus macrochirus.*	Fernando Veloso.	Coutière, 1902 *b*.
Thompsonia japonica...	*Pilumnus* sp.	Japan.	Häfele, 1911 *a*.
Thompsonia dofleini....	*Neptunus pelagicus.*	?	Häfele, 1911 *a*.
Thompsonia chuni	*Parapagurus.*	D. Tiefsee Exp.	Häfele, 1911 *a*.
Thompsonia japonica...	*Pilumnus* sp.	Japan.	Kruger, 1912.
Thompsonia japonica...	*Pagurus striatus.*	Japan.	Kruger, 1912.
Thompsonia affinis	*Diptychus* sp.	Japan.	Krüger, 1912.
Thompsonia sp.	*Synalpheus brucei.*	Torres Strait.	Potts, 1915.
Thompsonia sp.	*Actaea rüppellii.*	South Africa.	Potts, 1915.
Thompsonia sp.	*Thalamita prymna.*	Torres Strait.	Potts, 1915.
Thompsonia sp.	*Alpheus malleodigitus.*	Sulu Archipelago.	Van Kampen & Boschma, 1925.

It is improbable that all the specific names in this list are valid, but it is not possible to give distinct specific characters of all the different forms which have been described in detail. The chief peculiarities of these forms are given below.

Thompsonia globosa has a spheroidal shape, it possesses a long stalk (Kossmann, 1872). Two specimens only are known, which were attached to the legs of the crab *Melia tessellata*. They contained larvae. Length of the parasites (including the stalk) 1·8 mm., thickness 0·75 mm.

Concerning *Thompsonia sinensis*, described by Keppen (1877) in a paper in the Russian language, I cannot give any particulars, as I have not seen the paper. The title of this paper is found in Taschenberg's 'Bibliotheca Zoologica', vol. ii, p. 1227.

The specimens on *Alpheus* (*Betaeus*) *malleodigitus* mentioned by Bate (1888) were attached to the pleopods of the host. The parasites have an elongated shape and possess a short stalk with a proximal constriction. They occurred in fairly large numbers on their host. The size of the animals is not given. Bate writes: 'within each small sac was an embryo' (p. 566), but fig. 5 par. of pl. ci shows four of these embryos escaping from a fissure in the mantle.

Coutière (1902 *a–e*) describes three species of the genus *Thylacoplethus*, which was shown by Potts (1915) to be a synonym of *Thompsonia*. They are described as small ovoid sacs attached to the ventral surface of the abdominal segments of the hosts. One species (*Thylacoplethus haddoni*) has a length of 1·5 mm. and a thickness of 0·5 mm.; in another species (*T. heurteli*) these dimensions are 4·5 and 1 mm. respectively, whilst the third species (*T. edwardsi*) is intermediate in size between the two others. It is highly improbable that each of these forms represents a distinct species. Coutière does not give any specific characters, but perhaps he was convinced that each species of host had its own parasite (Giard's theory of the specificity of the parasites).

Three species of the genus *Thompsonia* have been described by Häfele (1911 *a*), viz. *T. japonica*, *T. dofleini*, and *T. chuni*. Of one of these, *T. japonica*, extensive material was available, and the author was thus able to describe all the peculiarities of this species in detail (Häfele, 1911 *b*). *Thompsonia japonica* has a comparatively long stalk, the body is more or less elongate; the dimensions are: length of the body 2 mm., thickness 0·8 mm., length of the stalk 1·2 mm. The parasites occur in great numbers on crabs of the genus *Pilumnus*, especially on the thoracic legs and on the abdomen. *Thompsonia dofleini* was found by Häfele in abundance (about 1500 specimens) on a specimen of *Neptunus pelagicus*. According to Häfele the shape of these parasites does not differ from that of *T. japonica*, but the figure of the species shows an animal of much more slender form. *T. dofleini* is somewhat smaller than *T. japonica*. A strange characteristic of this species is the presence of a genital pore, provided with a chitinous cover: a feature not known in other representatives of the genus. The third species described by Häfele, *Thompsonia chuni*, is a parasite of *Parapagurus*. It is much larger than *T. japonica* (Häfele does not give the

exact dimensions) and has a more or less spheroidal shape. The stalk is very short.

Krüger (1912) mentions *Pagurus striatus* as a new host for *Thompsonia japonica*. He writes that perhaps *T. japonica* is a synonym of Kossmann's *T. globosa*, as the shape of the parasites is very similar. In the same paper Krüger describes the new species *T. affinis*, a parasite of *Diptychus* sp., which differs from *T. japonica* by its spheroidal shape. In comparison with *T. japonica* the external sacs of *T. affinis* attain one-half to three-fourths of the size of the former. A further difference between the two forms is found in the cypris larvae: those of *T. japonica* possess pigmented eyes (*cf.* Häfele, 1911 *b*), whilst the larvae of *T. affinis* have eyes which are completely devoid of pigment. This character proves that the two forms are specifically distinct.

Potts (1915) describes the life-history of specimens of *Thompsonia* on *Synalpheus brucei*. These parasites are pear-shaped and about 1 mm. long. In the same paper mention is made of parasites of the genus on *Actaea rüppellii* (pear-shaped to round, 1 mm. long) and on *Thalamita prymna* (elongate, 3 mm. long). According to Potts, it is probable that the three forms are specifically distinct, but as specific characters are lacking he does not give specific names to these forms. The three forms of *Thompsonia* dealt with by Potts were attached to the appendages of their hosts.

The specimen of *Thompsonia* described by Van Kampen and Boschma (1925) is interesting in that it is a parasite of *Alpheus malleodigitus*, the species which was found by Bate (1888) infected with a fairly large number of other parasites of the same genus. The two forms are widely different. The 'Siboga' specimen (Van Kampen & Boschma, 1925) is solitary; it is attached to the ventral surface of an abdominal segment of the host; it is more or less globular and the stalk is not sharply limited from the rest of the body. On the other hand, the 'Challenger' specimen (Bate, 1888) is gregareous, attached to the appendages of the host, it is more or less elongate and has a short stalk surrounded by a groove at its place of attachment to the body. In all probability the two forms constitute different species of the genus. The 'Siboga' specimen has a length of 1·5 mm. (length of body including the stalk 2 mm.) and a thickness of 1·5 mm.

It is impossible to decide which of the named forms of *Thompsonia* are distinct species. For this reason I do not wish to give specific names to the specimens in the collection of the British Museum. In this collection there are two hosts, each with a great number of parasites (external sacs), with the following data:—

***Thompsonia* sp., on *Actaea rüppellii*, Scottsburgh, Natal, 1902, Natal Government Museum.**

***Thompsonia* sp., on *Synalpheus brucei*, Murray Is., Torres Strait, F. A. Potts.**

The characters of these specimens have been described by Potts (1915), and figures of the hosts with the attached parasites are found in the same paper (*l. c.*, pl. i, figs. 1, 2, & 4). Some of the parasites are rather larger than the dimensions given by Potts: those on *Synalpheus* may attain a length

of nearly 1·5 mm., those on *Actaea* a length of 2 mm. (not including the stalk). From each lot a few of the external sacs have been cut into series of sections, which, however, do not show many details of structure. The external sacs of the parasites of *Synalpheus* are filled with a great number of embryos in the egg-membrane, whilst those of the parasites of *Actaea* contain younger stages of development. In some specimens from *Actaea* a central hollow piece of tissue projects from the stalk into the mantle cavity (or the degenerated visceral mass ?) between the eggs.

In both these forms the external sacs are in a too far advanced state of development to show the particulars described by Häfele (1911 *b*) in the youngest stages of his *Thompsonia japonica*.

Literature cited.

Anderson, J. 1862. On the Anatomy of *Sacculina*, with a Description of the Species. *Ann. & Mag. Nat. Hist.* (3) vol. ix.

Annandale, N. 1911. Note on a Rhizocephalous Crustacean from Fresh Water and on some Specimens of the Order from Indian Seas. *Rec. Ind. Mus. Calcutta*, vol. vi.

Bate, C. Spence. 1888. Report on the Crustacea Macrura collected by H.M.S. 'Challenger' during the Years 1873–76.

Boschma, H. 1925. Rhizocephala of Curaçao. *Bijdr. Dierk. Amsterdam*, afl. 24.

—— 1927 *a*. On the Larval Forms of Rhizocephala. *Proc. Roy. Acad. Sci. Amsterdam*, vol. xxx.

—— 1927 *b*. Ueber europäische Formen der Gattung *Sacculina*. *Zool. Jahrb., Abt. Syst., Jena*, vol. liv.

—— 1927 *c*. Bemerkungen über Rhizocephalen des Golfes von Neapel. *Pubbl. Staz. zool. Napoli*, vol. viii.

—— 1928 *a*. Rhizocephala of the North Atlantic Region. *Danish Ingolf-Exped., Copenhagen*, vol. iii, no. 10.

—— 1928 *b*. The Rhizocephala of the Leiden Museum. *Zool. Meded., Leiden*, vol. xi.

—— 1929. *Galatheascus striatus*—a new Rhizocephalan. *J. Mar. Biol. Ass., Plymouth*, vol. xvi.

—— 1931 *a*. Rhizocephala. Papers from Dr. Th. Mortensen's Pacific Expedition, 1914–16. *Vidensk. Medd. naturh. Foren., Kjøbenhavn*, vol. lxxxix.

—— 1931 *b*. On the Identity of *Sacculina triangularis* and *Sacculina inflata*. *Proc. Roy. Soc. Edinb.*, vol. li.

—— 1931 c. Die Rhizocephalen der 'Siboga' Expedition, Supplement. '*Siboga' Expeditie*, monogr. 31 *bis*.

—— 1931 *d*. Rhizocéphales. Résultats Scientifiques du Voyage aux Indes Orientales Néerlandaises de LL. AA. RR. le Prince et la Princesse Léopold de Belgique. *Mém. Mus. Hist. nat. Belg.*, Hors Série, vol. iii, fasc. 8.

Coutière, H. 1902 *a*. Sur un type nouveau de Rhizocéphale, parasite des Alpheidae. *C. R. Ac. Sc. Paris*, vol. cxxxiv, p. 913.

—— 1902 *b*. Sur la morphologie interne du genre *Thylacoplethus*, parasite des Alpheidae. *Ibid.*, vol. cxxxiv, p. 1452.

—— 1902 *c*. Sur un nouveau type de Rhizocéphale, parasite des Alpheidae. *C. R. Soc. Biol. Paris*, vol. liv, p. 447.

—— 1902 *d*. Sur un nouveau type de Rhizocéphale grégaire parasite des Alpheidae (deuxième note). *Ibid.*, vol. liv, p. 625.

—— 1902 *e*. Sur un nouveau type de Rhizocéphale grégaire parasite des Alpheidae (troisième note). *Ibid.*, vol. liv, p. 724.

DELAGE, Y. 1884. Evolution de la Sacculine. *Arch. Zool. exp. gén. Paris,* (2) vol. ii.

DUBOSCQ, O. 1912. Sur les Peltogastrides des Côtes de France. *Arch. Zool. exp. gén. Paris,* (5) vol. ix, Notes et Revue.

FEUERBORN, H. J. 1932. Ein Rhizocephale und zwei Polychaeten aus dem Süsswasser von Java und Sumatra. *Verh. int. Vereinig. Limnol. Stuttgart,* vol. v.

FRAISSE, P. 1877. Die Gattung *Cryptoniscus* Fr. Müller. Inaugural Dissertation, Würzburg (also in : *Arb. zool.-zoot. Inst. Würzburg,* vol. iv, 1878).

GIARD, A., & BONNIER, J. 1887. Contribution à l'Étude des Bopyriens. *Trav. Sta. zool. Wimereux,* vol. v.

GUÉRIN-GANIVET, J. 1911. Contribution à l'Étude systématique et biologique des Rhizocéphales. *Trav. sci. Lab. Zool. Physiol. marit. Concarneau,* vol. iii.

—— 1912. Les Peltogastrides du Musée Océanographique de Monaco. *Ibid.,* vol. iv, and in *Bull. Inst. Océan. Monaco,* no. 244.

HÄFELE, F. 1911 *a.* Notizen über phylogenetisch interessante Rhizocephalen. *Zool. Anz., Leipzig,* vol. xxxviii.

—— 1911 *b.* Anatomie und Entwicklung eines neuen Rhizocephalen *Thompsonia japonica. Abh bayer. Akad. Wiss.* suppl.-vol. ii.

VAN KAMPEN, P. N., & BOSCHMA, H. 1925. Die Rhizocephalen der 'Siboga' Expedition. '*Siboga*' *Expeditie,* monogr. 31 *bis.*

KOSSMANN, R. 1872. Beiträge zur Anatomie der schmarotzenden Rankenfüssler. *Verh. med. phys. Ges. Würzburg,* N. F., vol. iii (also in : *Arb. zool.-zoot. Inst. Würzburg,* vol. i, 1874).

—— 1873. Suctoria und Lepadidae. Untersuchungen über die durch Parasitismus hervorgerufenen Umbildungen in der Familie der Pedunculata. Habilitationsschrift, Würzburg (also in : *Arb. zool.-zoot. Inst. Würzburg,* vol. i, 1874).

KRÜGER, P. 1912. Ueber ostasiatische Rhizocephalen. *Abh. bayer. Akad. Wiss.* suppl.-vol. ii.

LEUCKART, R. 1859. Carcinologisches. *Arch. Naturgesch. Berlin,* 25. Jahrg., vol. i.

LILLJEBORG, W. 1859. Les genres *Liriope* et *Peltogaster,* H. Rathke. *Nova Acta Soc. Sci. upsal.* (3) vol. iii.

MIERS, E. J. 1880. On a Collection of Crustacea from the Malaysian Region. Part 4. *Ann. & Mag. Nat. Hist.* (5) vol. v.

NORMAN, A. M., & SCOTT, TH. 1906. The Crustacea of Devon and Cornwall. London.

PÉREZ, CH. 1907. Sur l'existence du *Lernaeodiscus galatheae* Smith dans le golfe de Gascogne. *Proc.-verb. Soc. Sci. phys. nat. Bordeaux,* 1907.

—— 1922. Sur deux Crustacés parasites de la *Galathea squamifera* Leach. *Bull. Soc. zool. France,* vol. xlvii.

—— 1927. Notes sur les Épicarides et les Rhizocéphales des Côtes de France.—I. Sur l'' *Eupagurus bernhardus* ' et sur quelques-uns de ses parasites. *Bull. Soc. zool. France,* vol. lii.

—— 1928 *a.* Sur le cycle évolutif des Rhizocéphales du genre *Chlorogaster. C. R. Ac. Sc. Paris,* vol. clxxxvii.

—— 1928 *b.* Notes sur les Épicarides et les Rhizocéphales des Côtes de France.—II. Nouvelles observations sur les parasites de l'*Eupagurus bernhardus.*—III. L'*Eupagurus cuanensis* et ses parasites. *Bull. Soc. zool. France,* vol. liii.

—— 1931 *a.* Remplacement successif des sacs viscéraux chez les *Chlorogaster,* Rhizocéphales parasites des Pagures. *C. R. Ac. Sc. Paris,* vol. cxcii.

—— 1931 *b.* Organogénèse des bourgeons de remplacement chez les *Chlorogaster,* Rhizocéphales parasites des Pagures. *Ibid.,* vol. cxciii.

—— 1931 *c.* Notes sur les Épicarides et les Rhizocéphales des Côtes de France.—VII. *Peltogaster* et *Liriopsis. Bull. Soc. zool. France,* vol. lvi.

—— 1931 *d.* Les Rhizocéphales parasites des Pagures. *Actes Soc. Helvétique des Sc. Nat.,* 1931.

PÉREZ, CH., et BASSE, E. 1928. Sur un monstre double de Sacculine. *Bull. Soc. zool. France*, vol. liii.

PESTA, O. 1918. Die Decapodenfauna der Adria. Leipzig und Wien.

POPOV, W. 1929. Rhizocephala and Bopyridae of the Bay of Sevastopol. *Trav. Stat. biol. Sébastopol*, vol. i.

POTTS, F. A. 1915. On the Rhizocephalan Genus *Thompsonia* and its Relation to the Evolution of the Group. *Pap. Dep. Mar. Biol. Carnegie Inst. Washington*, vol. viii.

RATHKE, H. 1842. Beiträge zur vergleichenden Anatomie und Physiologie. Reisebemerkungen aus Skandinavien. *Schr. naturf. Ges. Danzig*, vol. iii.

SARS, M. 1870. Bidrag til Kundskab om Christianiafjordens Fauna.—II. Crustacea. *Nyt Mag. Naturv. Oslo*, vol. xvii.

SMITH, G. 1906. Rhizocephala. Fauna und Flora des Golfes von Neapel, 29. Monogr.

STEBBING, T. R. R. 1893. A History of Crustacea. Internat. Sci. Ser. vol. lxxiv. London.

THOMPSON, J. V. 1836. Natural History and Metamorphosis of an Anomalous Crustaceous Parasite of *Carcinus maenas*, the *Sacculina carcini*. *Entomol. Magaz.*, vol. iii.

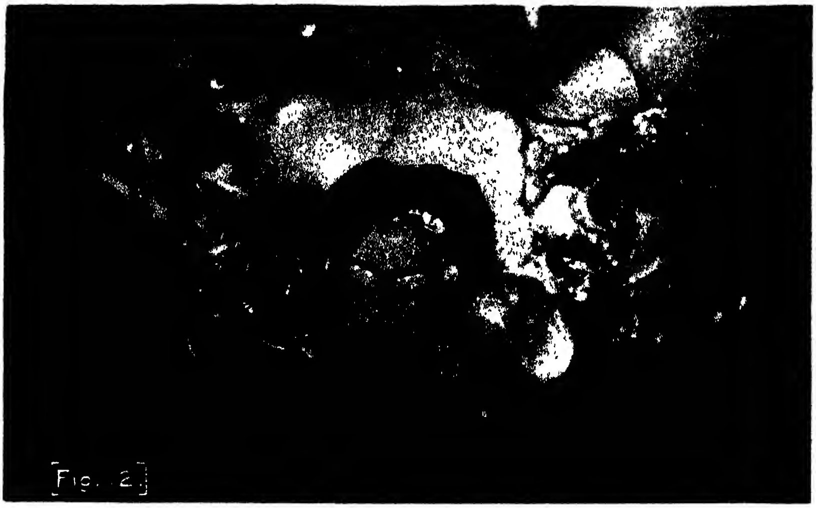

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Fig. 12. *SACCULINA SINENSIS*. Five specimens on the abdomen of *LEPTODIUS EXARATUS* × 4 5

Fig. 44. Two specimens of *PTYCHASCUS GLABER* on the abdomen of *ARATUS PISONII*. × 3·75

Tertiary Foraminifera of Victoria, Australia.—The Balcombian Deposits of Port Phillip. Part III.

By FREDERICK CHAPMAN, A.L.S., Hon.F.R.M.S., F.G.S., WALTER J. PARR, F.R.M.S., and ARTHUR C. COLLINS, A.R.V.I.A.

(PLATES 8–11)

[Read 4 January 1934]

INTRODUCTION.

This paper is the third instalment of a work dealing with the foraminifera of the Balcombian deposits of the Port Phillip area. When Part II appeared in this Journal in 1926, after a lapse of nineteen years, the hope was expressed that the description of these foraminifera would be completed shortly. Such would have been the case but for the classification and changes in nomenclature published shortly afterwards by Dr. J. A. Cushman. These were of such importance as to require immediate consideration, a task which has occupied much of the time of the first two of the present authors for several years. Whilst being very largely in agreement with Dr. Cushman, they have modified his classification by grouping the genera with agglutinated tests after those with a calcareous investment. The whole order has been divided into two superfamilies, and several of Dr. Cushman's groups have been re-arranged where the generic relationships appeared to warrant it. This arrangement will be followed for the remainder of the present work. As Brady's classification was used for Parts I and II, it is necessary for us to indicate the position of the genera already dealt with in that now followed. This is set out below.

In the notes on the distribution of the species included in this part, the records given are those which we have been able to verify by comparison with type-figures and, in most cases, topotype specimens. Only the more important references are quoted. While much new material has been studied, it has been taken from the same localities as previously, viz. Grice's Creek, Balcombe Bay, Kackeraboite Creek, and the Altona Bay Coal Shaft. In the systematic description of species, these are denoted G.C., B.B., K.C., and A.B.C.S. respectively, while the abbreviations used to indicate frequency of occurrence are :—v.c., very common ; c., common ; f., frequent ; r., rare ; v.r., very rare.

These notes on the Balcombian foraminifera of the Port Phillip area will be concluded in Part IV, which will cover all species not already considered and include also any necessary corrections in the earlier parts.

Order FORAMINIFERA.

Superfamily SPIRILLINOIDEA.

Family SPIRILLINIDAE.

Genus Spirillina Ehrenberg, 1843.

Included in this part.

Family LENTICULINIDAE.

Subfamily Lenticulininae.

Genus Lenticulina Lamarck, 1804.

Cristellaria spp. (pars), Journ. Linn. Soc. (London), Zool., vol. xxxvi, 1926, pp. 387–91.

Genus Hemicristellaria Stache, 1864.

Cristellaria spp. (pars), op. cit., pp. 387–88.

Genus Marginulina d'Orbigny, 1826.

Op. cit., p. 387.

Genus Vaginulina d'Orbigny, 1826.

Op. cit., p. 386.

Genus Dentalina d'Orbigny, 1826.

Nodosaria spp. (pars), op. cit., pp. 378–85.

Genus Nodosaria Lamarck, 1812.

Nodosaria spp. (pars), op. cit., pp. 378–85.

Genus Flabellina d'Orbigny, 1839.

Op. cit., p. 387.

Genus Frondicularia Defrance, 1824.

Op. cit., pp. 385, 386.

Genus Lingulina d'Orbigny, 1826.

Op. cit., p. 385.

Subfamily Lageninae.

Genus Lagena Walker & Jacob, 1798.

Op. cit., pp. 373–78, except *L. schlichti*, which is placed in *Ellipsolagena*.

Family POLYMORPHINIDAE.

Subfamily POLYMORPHININAE.

Genus GUTTULINA d'Orbigny, 1826.

Polymorphina spp. (pars), op. cit., pp. 391, 392.

Genus GLANDULINA d'Orbigny, 1826.

Nodosaria (*Glandulina*) *laevigata*, op. cit., p. 378, and *Polymorphina glandulinoides*, p. 392.

Genus SIGMOIDELLA Cushman and Ozawa, 1928.

Polymorphina elegantissima, op. cit., p. 392.

Subfamily RAMULININAE.

Genus RAMULINA Rupert Jones, 1875.

Op. cit., p. 394.

Family BULIMINIDAE.

Subfamily TURRILININAE.

Genus BULIMINELLA Cushman, 1911.

Bulimina, Journ. Linn. Soc. (London), Zool., vol. xxx, 1907, p. 31.

Genus CERATOBULIMINA Toula, 1920.

Included in this part.

Subfamily VIRGULININAE.

Genus VIRGULINA d'Orbigny, 1826.

Op. cit., p. 31.

Genus BOLIVINA d'Orbigny, 1839.

Op. cit., pp. 31, 32.

Subfamily UVIGERININAE.

Genus UVIGERINA d'Orbigny, 1826.

Op. cit., 1926, p. 393.

Genus TRIFARINA Cushman, 1923.

Op. cit., p. 386.

Family CASSIDULINIDAE.

Genus CASSIDULINA d'Orbigny, 1826.

Op. cit., p. 33, and this part.

Genus Cassidulinoides Cushman, 1927.

Included in this part.

Genus Ehrenbergina Reuss, 1850.

Op. cit., p. 33.

Family ELLIPSOIDINIDAE.

Genus Ellipsolagena A. Silvestri, 1923.

Lagena schlichti, op. cit., p. 377.

Families MELONIDAE and NUMMULITIDAE.

To be included in next part.

Families ROTALIIDAE, AMPHISTEGINIDAE, CALCARINIDAE, CHILOSTOMELLIDAE, GLOBIGERINIDAE, GLOBOROTALIIDAE, CIBICIDIDAE, RUPERTIIDAE, and POLYTREMIDAE.

Included in this part.

Superfamily AMMODISCOIDEA.

Family HYPERAMMINIDAE.

Subfamily Hyperammininae.

Genus Jaculella Brady, 1879.

Op. cit., 1907, p. 24.

Family CORNUSPIRIDAE.

Subfamily Cornuspirinae.

Genus Cornuspira Schultze, 1854.

Op. cit., pp. 22–4.

Subfamily Ophthalmidiinae.

Genus Spirophthalmidium Cushman, 1927.

Spiroloculina affixa, op. cit., p. 16.

Genus Planispirina Seguenza, 1880.

Op. cit., p. 21.

Family MILIOLIDAE.

Genus Quinqueloculina d'Orbigny, 1826.

Miliolina spp. (pars), op. cit., pp. 17–20.

Genus SPIROLOCULINA d'Orbigny, 1826.

Op. cit., pp. 16, 17, except *S. affixa*, which is a *Spirophthalmidium*.

Genus SIGMOÏLINA Schlumberger, 1887.

Op. cit., pp. 20, 21.

Genus TUBINELLA Rhumbler, 1906.

Articulina, op. cit., p. 22.

Genus TRILOCULINA d'Orbigny, 1826.

Miliolina spp. (pars), op. cit., pp. 17–20.

Genus PYRGO Defrance, 1824.

Biloculina spp., op. cit., pp. 13–16.

Family LITUOLIDAE.

Subfamily LITUOLINAE.

Genus LITUOLA Lamarck, 1804.

Op. cit., p. 25.

Family TEXTULARIIDAE.

Subfamily TEXTULARIINAE.

Genus TEXTULARIA Defrance, 1824.

Spiroplecta and *Textularia* spp., op. cit., pp. 25–8.

Genus BIGENERINA d'Orbigny, 1826.

Clavulina textularioidea, op. cit., p. 30.

Family VERNEUILINIDAE.

Genus GAUDRYINA d'Orbigny, 1839.

Op. cit., pp. 28, 29, except *G. siphonella*.

Genus HETEROSTOMELLA Reuss, 1865.

Gaudryina siphonella, op. cit., p. 28.

Genus CLAVULINA d'Orbigny, 1826.

Op. cit., pp. 29–31, except *C. textularioidea*, which is a *Bigenerina*.

Family TROCHAMMINIDAE.

Genus AMMOSPHAEROIDINA Cushman, 1910.

Haplophragmium, op. cit., p. 24.

Description of the species.

Family SPIRILLINIDAE.

Genus Spirillina Ehrenberg, 1843.

Spirillina vivipara Ehrenberg. (Pl. **8.** figs. 2 *a*, *b*.)

Spirillina vivipara Ehrenberg, 1843, p. 442, pl. iii, fig. 41; Cushman, 1922, p. 37, pl. v, fig. 7; Heron-Allen and Earland, 1924, p. 166.

Most of the examples are from the deeper water clays at Kackeraboite Creek and Balcombe Bay. This species occurs also in its typical form on the Victorian coast and elsewhere in the Pacific.

Occurrence.—B.B., r.; K.C., r.; A.B.C.S., v.r.

Spirillina pectinimarginata, sp. n. (Pl. **8.** figs. 3 *a*, *b*.)

Description.—Test small, thin, planospiral, composed of five to six coils, slowly increasing in diameter, faces flattened, sometimes slightly concave on both sides; sutures distinct, limbate; periphery sharp and armed with numerous short spines; wall thin, with the surface of each convolution transversely ridged; aperture apparently crescentic.

Diameter 0·28 mm.; thickness 0·025 mm.

Holotype (Chapman Coll.) from Oligocene (Balcombian), Kackeraboite Creek, Victoria.

Observations.—Examples of this minute species are not uncommon in the finest siftings from Balcombe Bay. We have other specimens from the Miocene of Torquay and Muddy Creek, near Hamilton, Victoria. The most closely related form is one to be described by two of us from an Antarctic dredging made by Sir Douglas Mawson. *S. spinigera* Chapman, from Funafuti, also resembles the present species, but has the basal side flattened or concave and the upper face convex.

Occurrence.—K.C., v.r.; B.B., f.

Spirillina decorata Brady. (Pl. **8.** figs. 1 *a*, *b*.)

Spirillina decorata Brady, 1884, p. 633, pl. lxxxv, figs. 22–25; Howchin, 1889, p. 11; Heron-Allen and Earland, 1922, p. 197; Cushman, 1931, p. 9, pl. ii, fig. 3.

This species is common in the Oligocene and Miocene of Victoria, although we do not know that it has been found elsewhere as a fossil. Brady's records were from the Atlantic and South Pacific Oceans, his figured specimens being from off the Canaries.

Howchin's note on his Muddy Creek examples is that they differ from the Recent form in possessing a rounded edge instead of being carinate, and in the absence of transverse furrows. According to Brady, the furrowing of the surface is characteristic of the thicker-walled specimens. Except that they are more compressed than usual, the specimens from the Balcombian are quite

typical. We have the species from shore-sand at Williamstown, Victoria, and in a dredging from 12½ miles east of Cape Byron, N.S.W., 111 fms.

Occurrence.—G.C., f.; B.B., f.; K.C., c.; A.B.C.S., f.

SPIRILLINA INAEQUALIS Brady. (Pl. **8.** figs. 4 *a–c.*)

Spirillina inaequalis Brady, 1879, p. 278, pl. viii, fig. 25, 1884, p. 631, pl. lxxxv, figs. 8–11; Heron-Allen and Earland, 1924, p. 167.

Small examples occur. Howchin had this species from the Lower Miocene beds at Muddy Creek. Heron-Allen and Earland's record was from the Lower Miocene of Batesford. As a living form, it is confined to the Indo-Pacific region. We have typical specimens from Gulf St. Vincent, South Australia.

Occurrence.—K.C., r.

SPIRILLINA LIMBATA Brady var. TUBERCULOLIMBATA Chapman. (Pl. **8.** figs. 5 *a, b.*)

Spirillina tuberculolimbata Chapman, 1900, p. 11, pl. i, figs. 8 *a–c.*

Spirillina limbata Brady var. *papillosa* Cushman, 1915, p. 6, pl. ii, fig. 4.

Spirillina limbata Brady var. *tuberculolimbata* Chapman; Cushman, 1921, p. 302, 1924, p. 31, pl. ix, figs. 4, 5.

The only specimen found is a megalospheric one with three coils. The growth-lines appear on both faces of the shell as somewhat oblique cross-bars. The inferior surface is in addition tuberculate, while the outer margin of each whorl is truncate and limbate as in typical *S. limbata.* This is the first record of this form as a fossil. The original specimens were from borings at, and dredgings off, Funafuti, and later records are from the same general region.

Family BULIMINIDAE.

Subfamily TURRILININAE.

Genus CERATOBULIMINA Toula, 1920.

CERATOBULIMINA HAUERII (d'Orbigny) var. AUSTRALIS Cushman and Harris. (Pl. **10.** figs. 26 *a–c.*)

Ceratobulimina hauerii (d'Orbigny) var. *australis* Cushman and Harris, 1927, p. 176, pl. xxix, figs. 10 *a–c*, pl. xxx, figs. 6–10.

This form was described from the Balcombian deposits of Grice's Creek. It is closely related to *C. hauerii* (d'Orb.), from the Miocene of the Vienna Basin, but is distinguished from that species by the narrower test and more elongate aperture. Brady has recorded (1884, p. 690, pl. cvi, figs. 6, 7) *Pulvinulina hauerii* (d'Orb.) from the South Pacific, but this is not d'Orbigny's species, and belongs to another genus, probably *Baggina.*

The Balcombian examples of the present form from Grice's Creek and Balcombe Bay are exceptionally well preserved and the thin plate covering the aperture during life is frequently present.

Occurrence.—G.C., c.; B.B., c.; K.C., r.; A.B.C.S., r.

Family CASSIDULINIDAE.

Genus Cassidulina d'Orbigny, 1826.

Cassidulina delicata Cushman. (Pl. **10.** figs. 27 *a–c*.)

Cassidulina delicata Cushman, 1927 (2), p. 168, pl. vi, fig. 5.

There is one specimen which appears to be identical with this species, described from the tropical Pacific, off Panama, in 428 fms. Dr. Cushman gives five other records of its occurrence from the region of lat. 43° N., off the west coast of America, at depths ranging from 227 to 900 fms. We have six examples of *C. delicata* from *Challenger* Station 185, off Raine Island, Torres Strait, 155 fms. Several of these are much compressed, while others are slightly inflated, as is the Balcombian specimen, but all have the peculiar aperture distinguishing this species from other species of *Cassidulina*. The outer margin of the aperture is transversely ribbed.

Occurrence.—G.C., v.r.

Genus Cassidulinoides Cushman, 1927.

Cassidulinoides chapmani Parr. (Pl. **10.** figs. 28 *a–c*.)

Cassidulina parkeriana Heron-Allen and Earland (*non* Brady), 1924, p. 146.
Cassidulinoides chapmani Parr, 1931, p. 99, text-figs. *a–c*; 1932, p. 231, pl. xxii, figs. 36, 37.

One typical example. This species has just been described from the Miocene of Rocky Point, Torquay, with the note that it occurs sparingly elsewhere in the Tertiary of Victoria. We have specimens from the Lower Miocene at Muddy Creek, Victoria. The two Recent records given by Parr were from east of Tasmania, 1320 fms., and shore-sand, Point Lonsdale, Victoria.

Occurrence.—A.B.C.S., v.r.

Family ROTALIIDAE.

Subfamily Discorbisinae.

Genus Patellina Williamson, 1858.

Patellina corrugata Williamson. (Pl. **8.** figs. 6 *a*, *b*.)

Patellina corrugata Williamson, 1858, p. 46, pl. iii, figs. 86–89; Heron-Allen and Earland, 1922, p. 198, pl. vii, fig. 5; Parr and Collins, 1930, p. 90, pl. iv, figs. 1–5.

The figured specimen agrees with examples at hand from the coast of Great Britain. This form is here associated with more finely subdivided specimens with a smaller proloculum such as were figured by Parr and Collins from off Gabo Island, Bass Strait (loc. cit.).

Occurrence.—B.B., v.r.; K.C., r.

Genus Discorbis Lamarck, 1804.

Discorbis bertheloti (d'Orbigny). (Pl. **9.** figs. 13 *a–c.*)

Rosalina bertheloti d'Orbigny, 1839 (2), p. 135, pl. i, figs. 28–30.
Discorbina bertheloti (d'Orb.); Brady, 1884, p. 650, pl. lxxxix, figs. 10–12; Howchin, 1889, p. 12.
Discorbis bertheloti (d'Orb.); Cushman, 1931, p. 16, pl. iii, figs. 2 *a–c.*

The specimens are typical. The species is found throughout the Victorian tertiary deposits, and exists as a living form in Bass Strait and elsewhere on the Australian coast.

Occurrence.—B.B., v.r.; K.C., r.; A.B.C.S., r.

Discorbis bertheloti (d'Orb.) var. papillata, nov. (Pl. **9.** figs. 14 *a–c.*)

Description.—Test ear-shaped in outline, trochoid, plano-convex, much compressed, composed of about one and a half coils, with six or seven chambers in the outer whorl, chambers rapidly increasing in size, sharply recurved, slightly inflated posteriorly on the dorsal side; periphery subacute, limbate, lobulated; suture-lines strongly limbate, on the superior face much raised and sometimes granulate; wall thin and finely perforate, the surface of the chambers on the dorsal side covered with granules of shell-substance, under surface slightly concave, smooth except for the umbilical region, translucent; aperture ventral, a slit at the base of the last-formed chamber.

Diameter 0·35 mm.

Holotype (Chapman Coll.) from Oligocene (Balcombian), Kackeraboite Creek, Victoria.

Observations.—The present form most closely resembles *D. bertheloti* var. *complanata*, described by Sidebottom (1918, p. 253, pl. vi, figs. 1–3) from off the east coast of New South Wales, 465 fms., but may be distinguished by the granulate surface and raised sutures on the dorsal side of the test. In this respect it is similar to *D. involuta*, described by Sidebottom (1918, p. 255, pl. vi, figs. 15–17) from the same dredging as *D. bertheloti* var. *complanata*, but this species has the chambers subdivided by subsidiary septa. *D. disparilis*, described by Heron-Allen and Earland (1922, p. 205, pl. vii, figs. 20–22) from off the Three Kings, N.Z., 100 fms., is also related, but the suture-lines of this species as well as those of *D. involuta* are gently recurved, not sharply reflexed as in the present form.

In addition to the records from the Balcombian, we have this variety from the Miocene of Batesford, where it is fairly common, and a single Recent specimen from *Challenger* Station 185, off Raine Island, 155 fms.

Occurrence.—B.B., r.; K.C., r.

Discorbis planoconcava (Chapman, Parr, and Collins). (Pl. **11.** figs. 40 *a–c.*)

Planulina biconcava (Jones and Parker) var. *planoconcava* Chapman; Parr and Collins MS., in Parr, 1932, p. 232, pl. xxii, figs. 34 *a–c.*

This form was at first considered by us to be a variety of the well-known Recent species *Planulina biconcava* (Jones & Parker), and was figured as such

by Parr in his paper on Victorian and South Australian shallow-water foraminifera. We are now of the opinion, after examining further examples, that it should be referred to *Discorbis*, and therefore give it specific rank. It bears a certain resemblance to *P. biconcava*, but the aperture, instead of being planuline, is situated on the inferior side of the test, in a slight depression, at the base of the inner margin of the last-formed chamber.

The essential features of this species are its flattened under side, concave superior face, lobulated and obliquely truncated outer margin, and limbate edges. Its diameter is usually about 0·4 mm.

The Recent specimen figured by Parr was from shore-sand, Point Lonsdale. The present examples are from Kackeraboite Creek and Balcombe Bay, at both of which localities it is rare. We also have the species from the Lower Beds (Miocene) at Muddy Creek.

DISCORBIS GLOBULARIS (d'Orbigny). (Pl. **8.** figs. 7 *a–c*.)

Rosalina globularis d'Orbigny, 1826, p. 271, no. 1, pl. xiii, figs. 1–4, Modèles, no. 69.
Discorbina globularis (d'Orb.) and vars.; Sidebottom, 1908, p. 11, pl. iii, figs. 3–8, pl. iv, figs. 1, 2.
Discorbina globularis (d'Orb.); Heron-Allen, 1917, J. R. M. S., pl. viii (reproduction of d'Orbigny's Planche inédite).

Judging by the figures given by d'Orbigny and by Sidebottom, this is a very variable species; it is therefore noteworthy that in the Tertiary of Victoria only one form is present. It is similar to figs. 7 & 10 of d'Orbigny's Planche inédite, reproduced by Heron-Allen, and to fig. 5 of plate iii of Sidebottom's work on the foraminifera of the Eastern Mediterranean (op. cit.). This has the superior surface more finely perforate than in typical *D. globularis*, and is more oval in outline. The early chambers of some of our fossil examples are stained a darker tint than the rest of the shell, as in living specimens.

Occurrence.—G.C., r.; B.B., r; K.C., r.; A.B.C.S., r.

DISCORBIS OPERCULARIS (d'Orbigny). (Pl. **8.** figs. 8 *a–c*.)

Rosalina opercularis d'Orbigny, 1826, p. 271, no. 7, 1839 (1), p. 101, pl. iii, figs. 24, 25.
Discorbis opercularis (d'Orb.); Cushman, 1915, p. 18, pl. xi, fig. 3.

The figured examples are in the plastogamic condition, the smaller shell having given off a number of tubular growths during the process. The types of this species were from the West Indies, and it is common on the coast of New South Wales and off New Zealand in moderately shallow water.

Occurrence.—B.B., v.r.; K.C., v.r.

DISCORBIS BALCOMBENSIS, sp. n. (Pl. **8.** figs. 10 *a–c*.)

Description.—Test small, plano-convex, almost circular in outline, with a sharp peripheral margin; consisting of about two and a half whorls, with six chambers in the last whorl, chambers usually no inflated; sutures on the superior face oblique, slightly recurved, distinct but not depressed, limbate, on the inferior face radial, much depressed; wall calcareous, comparatively

thick, in the outer whorl distinctly perforate, smooth, shining in some specimens; under surface with a slight development of exogenous shelly matter in the umbilical area; aperture an arched slit at the base of the last-formed chamber, near its umbilical margin.

Diameter 0·5 mm.; height 0·26 mm.

Holotype (Chapman Coll.) from Oligocene (Balcombian), Kackeraboite Creek, Victoria.

Observations.—This species is one of the *D. vesicularis* group, which is so well represented in Southern Australian shore-sands. It may be recognized by its small size, the almost total absence of the astral flaps, and generally poor development. *D. balcombensis* appears to be restricted to the Oligocene and Miocene of Victoria. It is common in the Lower Beds at Muddy Creek.

Occurrence.—B.B., r.; K.C., v.r.

DISCORBIS TUBERCULATA (Balkwill and Wright) var. AUSTRALIENSIS, nov. (Pl. **8.** figs. 9 *a–c.*)

Discorbis tuberculata Heron-Allen and Earland (*non* Balkwill and Wright), 1924, p. 169.

Description.—Variety differing from typical *D. tuberculata* (Balkwill & Wright, 1885, p. 350, pl. xiii, figs. 28–30) in having the aperture situated at the base of a loop-shaped depression, which is approximately parallel to the plane of coiling and midway between the periphery and the umbilical region.

Diameter 0·25 mm.

Holotype (Chapman Coll.) from Oligocene (Balcombian), Altona Bay Coal Shaft.

Observations.—We were at first inclined to record this as *D. tuberculata*, a species described from the Irish Sea, but, after studying a large quantity of material from the Australian region, as well as some typical examples of *D. tuberculata* from the Irish coast, for which we are indebted to Mr. Arthur Earland, F.R.M.S., we find that the peculiar apertural depression which is such a constant feature of the Australian specimens is absent from those from Ireland. This depression is suggestive of the genus *Pulvinulinella*, but the aperture itself is typically discorbine and not an elongated slit extending out towards the periphery of the shell.

The figured example is exceptionally well developed, but is not as typical as the more common smaller specimens, in which the tuberculation of the test is practically restricted to the superior surface. The tubercles are in reality very short tubules or deposits of shelly matter surrounding fairly coarse perforations in the wall.

We have also many examples of this variety from the Miocene of Batesford, from which *D. tuberculata* was recorded by Heron-Allen and Earland. It has been found by us as a Recent form in shore-sand from Williamstown, Victoria.

Occurrence.—B.B., r.; A.B.C.S., r.

Genus Heronallenia Chapman and Parr, 1931.

Heronallenia wilsoni (Heron-Allen and Earland). (Pl. 8. figs. 12 *a–c*.)

Discorbina wilsoni Heron-Allen and Earland, 1922, p. 206, pl. vii, figs. 17-19, 1924, p. 172.

Heronallenia wilsoni (H.-A. & E.); Chapman and Parr, 1931, p. 236, pl. ix, figs. 7, 8.

This species was described from the Antarctic dredgings of the *Terra Nova*. Heron-Allen and Earland's subsequent record was from the Miocene of Batesford, Victoria. It is not uncommon in many of the Victorian Miocene deposits, and we have a note of its occurrence as a Recent form in shore-sand from Point Lonsdale, Victoria.

The figured specimen bears several irregular papillae on the upper surface, but this condition is unusual in Balcombian and other examples of *H. wilsoni*.

Occurrence.—B.B., v.r.; K.C., v.r.

Heronallenia lingulata (Burrows and Holland). (Pl. 8. figs. 11 *a–c*.)

Discorbina lingulata Burrows and Holland, in Jones and others, 1895, pl. vii, figs 33 *a–c*, 1896, p. 297; Heron-Allen and Earland, 1922, p. 206, 1924, p. 172.

Heronallenia lingulata (B. & H.); Chapman and Parr, 1931, p. 236, pl. ix, fig. 6.

The structure of the test on the under surface of this species calls for some remark, as apparently we have here a secondary series of chambers which is not found in other members of the genus. The study of specimens mounted in glycerine shows that such is not the case. In the species of *Heronallenia*, each chamber extends backwards on the under surface and overlaps the one preceding. As the amount of overlap is greater in some species than in others, the shape of the inner margin varies correspondingly. In *H. wilsoni* it is in the form of the letter S, the strongly arched aperture forming the upper part of the letter, and the flap, overlying portion of the previous chamber, the lower part. In the present species, this margin is more sinuous. The aperture occupies the same relative position as in *H. wilsoni*, while the flap extends as a narrow tongue across the preceding chamber as far as the outer margin of the next chamber. The figured specimen shows this structure very well. It gives the appearance of there being two sets of chambers, an inner asterigerine series with radial sutures and an outer series of sinuous outline.

The small so-called vesicles on the upper surface to which the first two of the present authors referred in their description of the genus are also noteworthy. They are more correctly described by Burrows and Holland as bosses. One is visible on the surface of each chamber and indicates the position of an aperture, which, except in the case of the last-formed chamber, has been covered up by the subsequent growth of the shell. Our observations on specimens mounted in transparent media, and on others in which the wall has been carefully broken away, now lead us to regard them as being merely dome-shaped areas overlying the aperture beneath. They appear to represent an effort on the part of the organism to overcome the difficulty of providing for the free ingress and egress of the protoplasm, caused by the lowness of the chamber and the turning-in of the aperture.

The distribution of *H. lingulata* is peculiar. It was described from the Coralline Crag of Sutton, England, and all other records, including one by Burrows and Holland from the Lower Beds at Muddy Creek, Victoria, are from the Australian region. Its geological range here is from the Oligocene to the present day. It is widely distributed through the Victorian Tertiaries and still exists in Bass Strait and off New Zealand.

Occurrence.—G.C., v.r.; B.B., r.; A.B.C.S., v.r.

Subfamily Rotaliinae.

Genus Eponides Montfort, 1808.

Eponides concentricus (Parker and Jones). (Pl. **9.** figs. 17 *a–c*.)

Pulvinulina concentrica Parker and Jones MS., in Brady, 1864, p. 470, pl. xlviii, fig. 14; Chapman, 1910, p. 287.

Eponides concentricus (P. & J.); Cushman, 1931, p. 43, pl. ix, figs. 4, 5.

The figured specimen is an exceptionally fine example of this species, which is often common in the Miocene of Victoria and occurs in the living condition on the Australian coast.

Occurrence.—A.B.C.S., r.

Eponides repandus (Fichtel and Moll). (Pl. **9.** figs. 18 *a–c*.)

Nautilus repandus Fichtel and Moll, 1798, p. 35, pl. iii, figs. *a–d*.

Eponides repandus (F. & M.); Montfort, 1808, p. 127, 32e genre.

Pulvinulina repanda (F. & M.); Brady, 1884, p. 684, pl. civ, figs. 18 *a–c*; Howchin, 1889, p. 14.

Eponides repandus (F. & M.); Cushman and Kellett, 1929, p. 11, pl. iv, figs. 7 *a–c*.

The specimens are indistinguishable from Recent examples of this species. Howchin had *E. repandus* from both Lower and Upper Beds at Muddy Creek, and it is common in many Australian tertiary deposits. There is a tendency in some of the Balcombian examples for the aperture to become cribrate as in those figured by Cushman and Kellett from the coast of Ecuador.

Occurrence.—G.C., r.; B.B., f.; K.C., r.; A.B.C.S., f.

Genus Pulvinulinella Cushman, 1926.

(?) Pulvinulinella tenuimarginata, sp. n. (Pl. **9.** figs. 19 *a–c*.)

Description.—Test almost equally biconvex, trochoid, peripheral margin sharp, very slightly lobulated, whorls numbering about two and a half in the megalospheric form, with five or six chambers in the last-formed whorl, chambers not inflated; sutures distinct, on the dorsal side oblique, ventrally nearly radial and slightly depressed; wall smooth, finely perforate; aperture on the ventral side of the peripheral face, elongate, nearly parallel to the plane of coiling.

Diameter 0·5 mm.; height 0·18 mm.

Holotype (Chapman Coll.) from Oligocene (Balcombian), Kackeraboite Creek, Victoria.

Observations.—In most of its characters the present species resembles the genus *Pulvinulinella*, but, as the aperture is not loop-shaped, we prefer for the present to regard its generic position as doubtful. It often occurs in the Tertiary of Victoria, and we have Recent examples from Victorian shore-sands.

Occurrence.—G.C., c.; B.B., r.; K.C., r.; A.B.C.S., v.r.

Genus ROTALIA Lamarck, 1804.

ROTALIA HOWCHINI, sp. n. (Pl. 9. figs. 20 *a–c*.)

Rotalia papillosa var. *compressiuscula* Howchin (*non* Brady), 1889, p. 15.
Rotalia papillosa var. *compressiuscula* Brady; Howchin (*pars*), 1915, p. 350.
Rotalia reticula Heron-Allen and Earland (*non* Cushman), 1924, p. 181, pl. xiv, figs. 114–16.

Description.—Test usually almost equally biconvex, consisting of about 2½ to 3 whorls, with 10 to 12 chambers in the last-formed whorl, chambers not inflated; peripheral edge subacute, limbate; sutural lines limbate, raised, on the dorsal side recurved and much obscured by the reticulate surface-ornamentation, ventrally nearly radial and connected by numerous transverse ridges, umbilical region beaded; aperture an arched opening at the base of the last-formed chamber midway between the periphery and the umbilical area.

Diameter 0·9 mm.

Holotype (Chapman Coll.) from Oligocene (Balcombian), Altona Bay Coal Shaft.

Observations.—In the shape of its test, *R. howchini* is somewhat like *R. papillosa* var. *compressiuscula*, while the surface-ornament, particularly on the underside, resembles that of *R. clathrata* Brady. It is named in honour of Professor W. Howchin, who appears first to have recorded it as *R. papillosa* var. *compressiuscula*, from the Lower Beds at Muddy Creek. His note (loc. cit., *supra*) reads: 'A few not very characteristic examples occur. They are really passage forms between the present variety and *R. clathrata*.' Later, in 1915 (p. 350), he records the same form from two borings on the Lilydale Sheep-station, in South Australia, and observes: '. . . . strongly built examples occur which approximate to the *R. clathrata*, Brady, style of ornament, but with some differences. In this latter case, the segments of the inferior side are angulated radially as ridges, and are marked by a strong limbation, while between the limbate ridges are numerous transverse ridges . . .' Heron-Allen and Earland (1924, loc. cit.) have recorded the present species as *R. reticulata* Cushman, which was described (1918, Bull. 676, U.S. Geol. Survey, p. 66, pl. xxiv, fig. 3) from the Miocene of North Carolina. Their figures represent a species which, while resembling *R. reticulata* in form, is very differently ornamented, especially on the ventral surface.

We have also met with *R. howchini* in the Lower Miocene of Muddy Creek, Batesford, and Torquay. A closely related, if not identical species occurs in the Oligocene (Hutchinsonian) of New Zealand.

Occurrence.—G.C., r.; B.B., r.; K.C., c.; A.B.C.S., f.

ROTALIA BECCARII (Linné). (Pl. **9.** figs. 21 *a–c*.)

Nautilus beccarii Linné, 1767, p. 1162, 1788, p. 3370.

Rotalia beccarii (Linné); Cushman, 1931, p. 58, pl. xii, figs. 1–7, pl. xiii, figs. 1, 2.

This species is represented by a single specimen, which has a somewhat angulate peripheral margin; this type of shell occurs with the usual temperate form of *R. beccarii* on the Victorian coast, particularly at Altona Bay, and appears to be inseparable from it.

Occurrence.—A.B.C.S., v.r.

Subfamily SIPHONININAE.

Genus EPISTOMINA Terquem, 1883.

EPISTOMINA ELEGANS (d'Orbigny). (Pl. **9.** figs. 22 *a–c*.)

Rotalia (*Turbinulina*) *elegans* d'Orbigny, 1826, p. 276, no. 54.

Rotalina partschiana d'Orbigny, 1846, p. 153, pl. vii, figs. 28–30, pl. viii, figs. 1–3.

Epistomina elegans (d'Orb.), Cushman, 1927 (3), p. 182, pls. xxxi, xxxii.

The examples from Grice's Creek are exceptionally fine.

Occurrence.—G.C., c.; B.B., c.; K.C., r.; A.B.C.S., v.r.

Genus SIPHONINA Reuss, 1849.

SIPHONINA AUSTRALIS Cushman. (Pl. **10.** figs. 23 *a–c*.)

Truncatulina reticulata Howchin (non *Rotalina reticulata* Czjzek), 1889, p. 13; Chapman, 1910, p. 286; Heron-Allen and Earland, 1924, p. 177.

Siphonina australis Cushman, 1927 (1), p. 8, pl. ii, figs. 6 *a–c*, pl. iii, figs. 7 *a–c*, 8 *a–c*; Parr, 1930, p. 135.

The types of this species were from the Oligocene (Balcombian) of Muddy Creek. It appears to be confined to the Oligocene and Miocene of Australia and New Zealand, being replaced in later deposits by the related *S. tubulosa* Cushman.

Occurrence.—G.C., f.; B.B., f.; K.C., f.; A.B.C.S., r.

Subfamily CANCRISINAE.

Genus CANCRIS Montfort, 1808.

CANCRIS AURICULA (Fichtel and Moll). (Pl. **10.** figs. 24 *a–c*.)

Nautilus auricula var. α, Fichtel and Moll, 1798, p. 108, pl. xx, figs. *a–c*; var. β, pl. xx, figs. *d–f*.

Pulvinulina oblonga Williamson, 1858, p. 51, pl. iv, figs. 98–100.

Pulvinulina auricula (F. & M.); Brady, 1884, p. 688, pl. cvi, figs. 5 *a–c*; Howchin, 1889, p. 14.

Pulvinulina oblonga Will.; Howchin, 1889, p. 14.

Cancris auricula (F. & M.); Cushman, 1931, p. 72, pl. xv, figs. 1 *a–c*.

Except that the specimens are usually more elongated, they agree well with the figures given by Fichtel and Moll. This is a well-defined form in the Tertiary of Victoria and has been recorded from the Eocene of New Zealand (F. C.).

Occurrence.—G.C., f.; B.B., c.; K.C., f.; A.B.C.S., r.

Family AMPHISTEGINIDAE.

Genus AMPHISTEGINA d'Orbigny, 1826.

AMPHISTEGINA LESSONII d Orbigny. (Pl. **10.** figs. 25 *a–c*.)

Amphistegina lessonii d'Orbigny, 1826, p. 304, no. 3, pl. xvii, figs. 1–4, Modèles, no. 98; Howchin, 1889, p. 16.
Nummulites variolaria Howchin (*non* Sowerby), 1889, p. 16.
Amphistegina lessonii d'Orb.; Chapman, 1910, p. 294, pl. iii, fig. 6.

Two worn examples. This species is common in the shallow-water sediments forming the Lower Beds at Muddy Creek, from which it was recorded by Howchin. It is also abundant in the Miocene of Batesford.

Occurrence.—B.B., r.

Family CALCARINIDAE.

Genus CALCARINA d'Orbigny, 1826.

CALCARINA sp. aff. SPENGLERI (Linné). (Pl. **9.** figs. 15 *a–c*.)

The figured specimen does not agree with any published figure of *Calcarina*, and may be new. As it is the only one found, it is here recorded under the name of the species which it most closely resembles.

Occurrence.—B.B., v.r.

Family CHILOSTOMELLIDAE.

Subfamily ALLOMORPHINELLINAE.

Genus PULLENIA Parker and Jones, 1860.

PULLENIA QUINQUELOBA (Reuss). (Pl. **10.** figs. 29 *a*, *b*.)

Nonionina quinqueloba Reuss, 1851, p. 71, pl. v, figs. 31 *a*, *b*.
Pullenia quinqueloba (Reuss); Brady, 1884, p. 617, pl. lxxxiv, figs. 14, 15; Heron-Allen and Earland, 1924, p. 166.

Excellent specimens occur here and elsewhere in the Tertiary of Victoria. Heron-Allen and Earland's record was from the Miocene of Batesford.

Occurrence.—G.C., f.; B.B., f.; K.C., r.; A.B.C.S., f.

PULLENIA SPHAEROIDES (d'Orbigny). (Pl. **10.** figs. 30 *a–b*.)

Nonionina sphaeroides d'Orbigny, 1826, p. 293, no. 1, Modèles, no. 43.
Pullenia sphaeroides (d'Orb.); Brady, 1884, p. 615, pl. lxxxiv, figs. 12, 13.

Good specimens were met with. This species has a distribution similar to that of *P. quinqueloba* in the Tertiary of Victoria, but is never so common.

Occurrence.—K.C., f.; A.B.C.S., r.

Genus SPHAEROIDINA d'Orbigny, 1826.

SPHAEROIDINA BULLOIDES d'Orbigny. (Pl. **10.** figs. 31 *a*, *b*.)

Sphaeroidina bulloides d'Orbigny, 1826, p. 267, no. 1, Modèles, no. 65; Brady, 1884, p. 620, pl. lxxxiv, figs. 1–7; Howchin, 1889, p. 11.

The examples are characteristic.

Occurrence.—G.C., c.; B.B., r.; K.C., c.; A.B.C.S., f.

Family GLOBIGERINIDAE.

Subfamily Globigerininae.

Genus Globigerina d'Orbigny, 1826.

Globigerina bulloides d'Orbigny. (Pl. **10.** figs. 32 *a–c*, 34 *a–c*.)

Globigerina bulloides d'Orbigny, 1826, p. 277, no. 1, Modèles, Nos. 17 & 76; Fornasini, 1899, p. 579, pl. ii, figs. 1, 3–8, pl. iv, fig. 2.

Small examples occur.

Occurrence.—G.C., f.; B.B., f.; K.C., f.; A.B.C.S., f.

Subfamily Orbulininae.

Genus Orbulina d'Orbigny, 1839.

Orbulina universa d'Orbigny. (Pl. **10.** figs. 33, 35.)

Orbulina universa d'Orbigny, 1839 (1), p. 3, pl. i, fig. 1: Brady, 1884, p. 608, pl. lxxviii, pl. lxxxi, figs. 8–26, pl. lxxxii, figs. 1–3; Howchin, 1889, p. 11.

Pl. **10.** fig. 33 represents a two-chambered specimen. These occur occasionally in Recent dredgings, in which *O. universa* is common. The species is often met with in the Tertiary of Victoria, but is unusually rare in similar deposits in New Zealand, only two examples, one from the Upper Eocene and the other from the Miocene, having been recorded (F. C.).

Occurrence.—G.C., c.; B.B., v.r.; K.C., c.; A.B.C.S., f.

Family GLOBOROTALIIDAE.

Genus Globorotalia Cushman, 1927.

Globorotalia dehiscens, sp. n. (Pl. **11.** figs. 36 *a–c*.)

Description.—Test subconical, about as broad as high, the dorsal side flattened or slightly convex, the ventral side strongly convex and deeply umbilicate, margin rounded, composed of several whorls with four chambers in the last-formed one, chambers increasing quickly in size and height as added, well inflated, and separated along their inner margins by deep fissures; sutures radial, depressed; surface reticulate or slightly papillate, the apertural face being finely punctate; aperture an elongate slit extending almost the full length of the inner margin of the last-formed chamber and opening into the umbilical cavity.

Diameter 0·55 mm.

Holotype (Chapman Coll.) from Oligocene (Balcombian), Kackeraboite Creek, Victoria.

Observations.—This species is distinct from any previously described form, and not likely to be mistaken for any other. As with many other species found in the Tertiary of Victoria, it is confined to the Oligocene and Miocene.

Occurrence.—G.C., f.; B.B., r.; K.C., r.; A.B.C.S., v.r.

GLOBOROTALIA SCITULA (Brady). (Pl. **11.** figs. 37 *a–c*.)

Pulvinulina scitula Brady, 1882, p. 716.

Pulvinulina patagonica Brady (non *Rotalina patagonica* d'Orbigny), 1884, p. 693, pl. ciii, figs. 7 *a–c*.

Globorotalia scitula (Brady); Cushman, 1927 (2), p. 175, 1931, p. 100, pl. xvii, figs. 5 *a–c*.

Typical examples are rare. This appears to be the first record of this species as a fossil.

Occurrence. G.C., r.

Family CIBICIDIDAE.

Subfamily ANOMALININAE.

Genus ANOMALINA d'Orbigny, 1826.

ANOMALINA ROTULA d'Orbigny. (Pl. **11.** figs. 38 *a–c*.)

Anomalina rotula d'Orbigny, 1846, p. 172, pl. x, figs. 10–12; Macfadyen, 1930, p. 99, pl. iv, figs. 10 *a–c*.

The majority of the specimens are in close agreement with d'Orbigny's type-figure, which represents a form on the ventral side of which only the last-formed whorl is visible. The figured example is unfortunately less typical, as the earlier coils are exposed on both faces. Macfadyen has figured a similar specimen from the Miocene of Egypt.

A. rotula was described from the Vienna Basin Tertiaries, and has since been recorded by Howchin from the Lower Beds (of Miocene age) at Muddy Creek, Victoria. It also appears to be present in the Miocene of New Zealand.

Occurrence.—G.C., c.; B.B., f.; K.C., f.; A.B.C.S., f.

ANOMALINA GLABRATA Cushman. (Pl. **11.** figs. 39 *a–c*.)

Anomalina glabrata Cushman, 1924, p. 39, pl. xii, figs. 5–7; Parr, 1926, p. 175 Cushman and Laiming, 1931, p. 118, pl. xiv, figs. 1 *a–c*.

The specimens are very typical. This species is well represented in the Tertiary of Victoria. The type-specimens were from off Samoa. Parr has recorded it from the Miocene of Victoria, and Cushman and Laiming have since had it from the Miocene of California.

Occurrence.—G.C., f.; B.B., f.; K.C., f.; A.B.C.S., f.

Subfamily CIBICIDINAE.

Genus CIBICIDES Montfort, 1808.

CIBICIDES LOBATULUS (Walker and Jacob). (Pl. **11.** figs. 41 *a–c*.)

Nautilus lobatulus Walker and Jacob, 1798, p. 642, pl. xiv, fig. 36.

Truncatulina lobatula (W. & J.); Williamson, 1858, p. 59, pl. v, figs. 121–3; Howchin, 1889, p. 13.

Cibicides lobatula (W. & J.); Cushman, 1931, p. 118, pl. xxi, figs. 3 *a–c*.

This species is represented here by a few neatly-built examples similar

in form to those figured by Williamson. Its geological history in Australia begins in the Gingin Chalk.

Occurrence.—G.C., r.; K.C., r.

CIBICIDES UNGERIANUS (d'Orbigny). (Pl. **11.** figs. 42 *a–c*.)

Rotalina ungeriana d'Orbigny, 1846, p. 157, pl. viii, figs. 16–18.
Truncatulina ungeriana (d'Orb.); Howchin, 1889, p. 13.

After comparing our specimens with topotype examples of *C. ungerianus* from the Vienna Basin Tertiaries, we believe that, although not quite typical, they are in closer agreement with this species than any other with which we are acquainted. The Recent form figured by Brady (1884, pl. xciv, figs. 9 *a–c*) as *Truncatulina ungeriana* (d'Orb.) is a different species which Dr. Cushman considers (1931, p. 123) to be identical with his *C. pseudoungerianus*, from the Oligocene of the United States.

Occurrence.—G.C., c.; B.B., c.; K.C., f.

CIBICIDES VICTORIENSIS, sp. n. (Pl. **9.** figs. 16 *a–c*.)

Truncatulina mundula Chapman and Crespin (*non* Brady, Parker, and Jones), 1928, p. 88.

Description.—Test unequally biconvex, but variable in this respect, dorsal side usually slightly convex, umbonate in the centre, to which the last whorl forms a flattened border, ventral side slightly umbilicate; periphery bluntly angled; chambers numerous, twelve to fourteen in the adult whorl, of uniform shape, increasing in size very gradually, fairly distinct except on the dorsal side, where those in the early whorls are obscured by the limbation of the test; sutures on the dorsal side oblique and gently recurved, on the ventral side slightly recurved and limbate; wall smooth, distinctly perforate; aperture peripheral and extending along the inner dorsal margin of the chamber, generally with a raised lip.

Diameter up to 1·3 mm.; height to 0·7 mm.

Holotype (Chapman Coll.) from Oliogcene (Balcombian), Kackeraboite Creek, Victoria.

Observations.—This species was recorded by Chapman and Crespin, in the report on the Sorrento Bore (op. cit., *supra*), as *Truncatulina mundula*, a Recent form described by Brady, Parker, and Jones from the Abrolhos Bank, in the South Atlantic, but the latter is much smaller, being only 0·5 mm. in diameter and with fewer chambers to a whorl. *Cibicides praecinctus* (Karrer) and *C. dutemplei* (d'Orbigny), both of which were described from the Miocene of Central Europe, more closely resemble the present species; the consistently greater number of chambers to a whorl in *C. victoriensis* is, however, distinctive.

Truncatulina mundula var. *carinata*, which was described by Chapman and Crespin (op. cit., p. 89, pl. ii, fig 6) from the Sorrento we regard as so distinct as to merit specific rank. Since Terquem had already used the name *carinata* for a different species, which he obtained from the Eocene of the Paris Basin,

we here rename the Australian form *Cibicides sorrentae.* It has not occurred in any of the material examined for the present report; it was met with only sparingly in the core-material from the Sorrento Boring.

The present species is subject to a considerable amount of variation as regards the convexity and limbation of the dorsal surface. The figured example is almost plano-convex and with little limbation, but generally the dorsal side is umbonate and with a considerable amount of exogenous matter along the spiral suture.

C. victoriensis appears to occur only in the Oligocene and Miocene of Victoria. It was common in the Sorrento Bore, the best examples being from the Oligocene. We have typical specimens from the Moorabool Valley Tertiaries, near Geelong.

Occurrence.—A.B.C.S., r.; G.C., r.; K.C., c.; B.B., c.

Genus DYOCIBICIDES Cushman and Valentine, 1930.

DYOCIBICIDES BISERIALIS Cushman and Valentine. (Pl. **11.** figs. 43 *a–c.*)

Dyocibicides biserialis Cushman and Valentine, 1930, p. 31, pl. x, figs. 1, 2 *a, b*; Cushman, 1931, p. 126, pl. xxiv, fig. 2.

The examples are small. The types of this species were from shallow water off Southern California. It has since been recorded by Dr. Cushman from the Miocene of Florida, and as a Recent form from off the eastern coast of U.S.A., 276 fms. Some, if not all, of the records of *Truncatulina variabilis* d'Orb. from the Australian region relate to the present species. We have excellent material from the coast of New South Wales.

Occurrence.—G.C., r.; B.B., r.; K.C., v.r.; A.B.C.S., v.r.

Family RUPERTIIDAE.

Genus CARPENTERIA Gray, 1858.

CARPENTERIA PROTEIFORMIS Göes. (Pl. **11.** fig. 45.)

Carpenteria balaniformis Gray var. *proteiformis* Goës, 1882, p. 94, pl. vi, figs. 208–14, pl. vii, figs. 215–19.

Carpenteria proteiformis Goës; Brady, 1884, p. 679, pl. xcvii, figs. 8–14; Howchin, 1889, p. 14; Chapman, 1926, p. 81, pl. xvi, fig. 7.

Typical examples occur. The first record of this species as a fossil is that of Howchin from the Lower Beds at Muddy Creek, Victoria. It has since proved to be common in many East Indian, Australian, and New Zealand tertiary foraminiferal faunas.

Occurrence.—B.B., v.r.; A.B.C.S., v.r.

CARPENTERIA ROTALIFORMIS Chapman and Crespin. (Pl. **11.** figs. 44 *a–c.*)

Carpenteria proteiformis Goës; Chapman (*pars*), 1913, p. 171, pl. xvi, fig. 7.

Carpenteria rotaliformis Chapman and Crespin, 1930, p. 98, pl. v, figs. 7, 8.

Typical examples occur in the Balcombian of Victoria. This species consists of about two rotaline coils, each with five globular chambers, the median

portion of the superior (free) face being slightly depressed. In its habit of growth it is very distinct from other described species of the genus. The test is adherent by the chambers of the first whorl only; the growth of the remaining chambers is upward and away from the object of attachment. We have thus a species linking the more typical *Carpenteriae* with the non-adherent *Victoriellae*.

C. rotaliformis was described from borings in the Victorian Tertiaries.

Occurrence.—G.C., r.; B.B., r.

Family POLYTREMIDAE.

Genus Polytrema Risso, 1826.

Polytrema miniaceum (Pallas). (Pl. 11. figs. 46 *a*, *b*.)

Millepora miniacea Pallas, Elenchus Zoophytorum (Hague, 1766), p. 251.
Polytrema miniaceum (Pallas); Heron-Allen and Earland, 1922, p. 221, pl. viii.

The only specimens are from the shallower-water deposits at Balcombe Bay. Except that they are colourless, they are very typical, the finely perforate surface and the larger foramina being as perfectly preserved as in Recent material. In two of the larger examples there has been deposition of shell-matter in solid layers on the surface, leading to the formation of depressed pits similar to those figured by Heron-Allen and Earland (op. cit., p. 224, pl. viii, fig. 26) from off New Zealand. We were at first inclined to attribute these specimens to *Homotrema*, but found that the whole surface of the test was perforated and that the larger foramina characteristic of *Polytrema* were also present. We have since observed the same structure in some beautiful examples of *P. miniaceum* collected by the late Edward Halkyard at Beaulieu, near Nice, on the Mediterranean.

Howchin's record (1889, p. 14) of *P. miniaceum* var. *alba* Carter, from the Lower Beds at Muddy Creek almost certainly refer to the present species, examples of which we have from the same locality.

Occurrence.—B.B., r.

Literature referred to in the Text.

Balkwill, F. P., & Wright, J. 1885. Report on some Recent Foraminifera found off the Coast of Dublin and in the Irish Sea. *Trans. Roy. Irish Acad.*, vol. xxviii (Science), pp. 317–68, pls. xii–xiv.

Brady, H. B. 1864. Contributions to our Knowledge of the Foraminifera. On the Rhizopodal Fauna of the Shetlands. *Trans. Linn. Soc. (London)*, vol. xxiv. pp. 463–75, pl. xlviii.

—— 1879, &c. Notes on some of the Reticularian Rhizopoda of the *Challenger* Expedition. *Quart. Journ. Micr. Sci. (London)*, vol. xix, pp. 20–63, pls. iii–v, pp. 261–99, pl. viii. Continued in vol. xxi, 1881, pp. 37–71.

—— 1882. Report on the Foraminifera, in Comm. Tizard and John Murray: Exploration of the Färoe Channel during the Summer of 1880 in H.M. Hired Ship *Knight Errant*. *Proc. Roy. Soc. Edinb.*, vol. xi, pp. 708–17, pl. vi.

BRADY, H. B. 1884. Report on the Scientific Results of the Voyage of H.M.S. *Challenger* (Zoology), vol. ix. Report on the Foraminifera, 2 vols., 4to, text and plates. London.

——, PARKER, W. K., & JONES, T. R. 1888. On some Foraminifera from the Abrolhos Bank. *Trans. Zool. Soc. (London)*, vol. xii, pp. 211–39, pls. xl–xlvi.

CHAPMAN, F. 1900. On some new and interesting Foraminifera from the Funafuti Atoll, Ellice Islands. *Journ. Linn. Soc. Lond. (Zoology)*, vol. xxviii, pp. 1–27, pls. i–iv.

—— 1907, &c. Tertiary Foraminifera of Victoria, Australia. The Balcombian Deposits of Port Phillip.—Part I. Ibid., vol. xxx, pp. 10–35, pls. i–iv. Part II, by F. CHAPMAN and W. J. PARR, vol. xxxvi, 1926, pp. 373–97, pls. xvii–xxi.

—— 1910. A Study of the Batesford Limestone. *Proc. Roy. Soc. Vict.*, vol. xxii (n. s.), pt. 2, 1909 (1910), pp. 263–314, pls. lii–lv.

—— 1913. Descriptions of new and rare Fossils obtained by deep Boring in the Mallee.—Part I. Plantae; and Rhizopoda to Brachiopoda. Ibid., vol. xxvi (n. s.), pt. 1, pp. 165–91, pls. xvi–xix.

—— 1926. The Cretaceous and Tertiary Foraminifera of New Zealand. *N.Z. Geol. Survey Pal. Bull.* No. 11, pp. 1–119, pls. i–xxii.

——, & CRESPIN, I., in F. CHAPMAN and others. 1928. The Sorrento Bore, Mornington Peninsula, with a Description of new or little-known Fossils. *Rec. Geol. Survey Vict.*, vol. v, pt. 1, pp. 1–195, pls. i–xii (Foraminifera on pls. i and ii).

——, —— 1930. Rare Foraminifera from deep Borings in the Victorian Tertiaries.—Part II. *Proc. Roy. Soc. Vict.*, vol. xliii (n. s.), pt. 1, pp. 96–100, pl. v.

——, & PARR, W. J. 1931. Notes on new and aberrant Types of Foraminifera. Ibid., vol. xliii (n. s.), pt. 2, 1930 (1931), pp. 236–40, pl. ix.

CUSHMAN, J. A. 1914. A Monograph of the Foraminifera of the North Pacific Ocean.—Part 4. Chilostomellidae, Globigerinidae, Nummulitidae. *U.S. Nat. Mus. Bull.* 71, pt. 4.

—— 1915. Ibid.—Part 5. Rotaliidae. Ibid., pt. 5.

—— 1921. Foraminifera of the Philippine and adjacent Seas. *Bull.* 100, *U.S. Nat. Mus.*, vol. iv, 608 pp., 52 text-figs., 100 pls.

—— 1922. Shallow-water Foraminifera of the Tortugas Region. *Publ.* 311, *Carnegie Inst. Washington.*

—— 1924. Samoan Foraminifera. *Publ.* 342, *Carnegie Inst. Washington.*

—— 1927 *a*. Foraminifera of the Genus *Siphonina* and related Genera. *Proc. U.S. Nat. Mus.*, vol. lxxii, Art. 20, pp. 1–15, pls. i–iv.

—— 1927 *b*. Recent Foraminifera from off the West Coast of America. *Bull. Scripps Inst. Oceanog.*, Tech. Ser., vol. i, no. 10, pp. 119–88, pls. i–vi.

—— 1927 *c*. *Epistomina elegans* (d'Orbigny) and *E. partschiana* (d'Orbigny). *Contr. Cushm. Lab. Foram. Research*, vol. iii, pt. 4, pp. 180–85, pls. xxxi, xxxii.

—— 1931. The Foraminifera of the Atlantic Ocean.—Part 8. Rotaliidae, Amphisteginidae, Calcarinidae, Cymbaloporettidae, Globorotaliidae, Anomalinidae, Planorbulinidae, Rupertiidae, and Homotremidae. *Bull.* 104, *U.S. Nat. Mus.*, pt. 8.

——, & HARRIS, R. W. 1927. Some Notes on the Genus *Ceratobulimina*. *Contr. Cushm. Lab. Foram. Res.*, vol. iii, pt. 4, pp. 171–77, pls. xxix–xxx.

——, & KELLETT, BETTY. 1929. Recent Foraminifera from the West Coast of South America. *Proc. U.S. Nat. Mus.*, vol. lxxv, Art. 25, pp. 1–16, pls. i–v.

——, & LAIMING, B. 1931. Miocene Foraminifera from Los Sauces Creek, Ventura County, California. *Journ. Pal.*, vol. v, no. 2, pp. 79–118, pls. ix–xiv.

——, & VALENTINE, W. W. 1930. Shallow-water Foraminifera from the Channel Islands of Southern California. *Contrbns. Dept. Geol. Stanford Univ.*, vol. i, no. 1, pp. 1–51, pls. i–x.

EHRENBERG, C. G. 1843. Verbreitung und Einfluss des Mikroskopische Lebens in Sud- und Nord-Amerika. *Abhandl. kgl. Akad. der Wiss. (Berlin)* (for 1841), pp. 291–446, pls. i–iv.

FICHTEL, L. VON, & MOLL, J. P. C. VON. 1798. Testacea Microscopica aliaque minuta, etc. Vienna (Second issue, 1803.)

FORNASINI, C. 1899. Globigerine Adriatiche. *Mem. R. Accad. Sci. Ist Bologna*, ser. 5, vol. vii, pp. 575–86, pls. i–iii.

GOËS, A. 1882. On the Reticularian Rhizopoda of the Caribbean Sea. *Kongl. Svenska Vetenskaps-Akademiens Handlingar*, vol. xix, no. 4, pp. 1–151, pls. i–xii.

HERON-ALLEN, E., & EARLAND, A. 1922. British Antarctic (*Terra Nova*) Expedition, 1910. *Nat. Hist. Rep. Zoology*, vol. vi, pt. 2, Foraminifera, pp. 25–268, pls. i–viii.

——, —— 1924. The Miocene Foraminifera of the 'Filter' Quarry, Moorabool River, Victoria, Australia. *Journ. Roy. Micr. Soc.*, 1924, pp. 121–86, pls. vii–xiv.

HOFKER, J. 1927. The Foraminifera of the *Siboga* Expedition.—Part I. Families Tinoporidae, Rotaliidae, Nummulitidae, Amphisteginidae. *Mon.* iv, '*Siboga*' *Exped.*, pt. 1, pp. 1–78, pls. i–xxxviii, text-figs.

HOWCHIN, W. 1889. The Foraminifera of the older Tertiary of Australia (No. 1, Muddy Creek, Victoria). *Trans. Roy. Soc. S. Aust.*, vol. xii, pp. 1–20, pl. i.

—— 1915. A List of Foraminifera and other Organic Remains obtained from Two Borings on the Lilydale Sheep-station. Ibid., vol. xxxix, pp. 345–51.

JONES, T. R., & others. 1895, &c. A Monograph of the Foraminifera of the Crag. (Paleontographical Soc. Mon.), pt. ii, 1895, pp. 73–210, pls. v–vii, pt. iii, 1896, pp. 211–314.

LINNÉ, C. VON. 1767, &c. Systema Naturae, Edn. xii, Leipzig, 1767; edn. xiii by J. F. Gmelin, Leipzig, 1788.

MACFADYEN, W. A. 1931. Miocene Foraminifera from the Clysmic Area of Egypt and Sinai. Survey of Egypt—Geological Survey. Government Press, Cairo, 1930 (May 1931), pp. 1–149, pls. i–iv.

MONTFORT, D. DE. 1808–1810. Conchyliologie Systématique et Classification Méthodique des Coquilles, etc., 2 vols. Paris, 1808–1810.

ORBIGNY, A. D. D'. 1826. Tableau Méthodique de la Classe des Céphalopodes. *Ann. Sci. Naturelles* (*Paris*), vol. vii, pp. 245–314, pls. x–xvii.

—— 1839 *a*. Foraminifères. In Ramon de la Sagra: Histoire Physique, Politique et Naturelle de l'Ile de Cuba. Text 8vo and plates fol. Paris, 1839. (Spanish edn., Paris, 1840.)

—— 1839 *b*. Foraminifères. In Barker-Webb and Berthelot, Histoire Naturelle des Iles Canaries, vol. ii, pt. 2, pp. 119–46, 3 pls. Paris.

—— 1846. Foraminifères Fossiles du Bassin Tertiaire de Vienne. 4to, 21 pls. Paris.

PARR, W. J. 1926. Some Additional Microzoa from the Red Limestone at Grange Burn, Vic. *Vict. Naturalist*, vol. xliii, pp. 17–20.

—— 1930. In C. W. Firth: The Geology of the North-west Portion of Manukau County, Auckland, N.Z. *Trans. N.Z. Inst.*, vol. lxi, pp. 85–137, pls. vii–xxiii (Foraminifera on pp. 134, 135).

—— 1931. A new Species of the Foraminifera. *Cassidulinoides chapmani*. *Vict. Nat.*, vol. xlviii, pp. 99–100, text-figs. *a–c*.

—— 1932. Victorian and South Australian Shallow-water Foraminifera. *Proc. Roy. Soc. Vict.*, vol. xliv (n. s.), pt. 2 (for 1931), pp. 218–34, pls. xxi–xxii.

PARR, W. J., & COLLINS, A. C. 1930. Notes on Australian and New Zealand Foraminifera.—No. 1. The Species of *Patellina* and *Patellinella*, with a Description of a new Genus, *Annulopatellina*. *Proc. Roy. Soc. Vict.*, vol. xliii (n. s.), pt. 1, pp. 89–95, pl. iv.

REUSS, A. E. 1851. Ueber die fossilen Foraminiferen und Entomostraceen der Septarienthone der Umgegend von Berlin. *Zeitschr. Deutsch. Geol. Ges.* (*Berlin*), vol. iii, pp. 49–92, pls. iii–vii.

SIDEBOTTOM, H. 1908. Report on the Recent Foraminifera from the Coast of the I land of Delos (Grecian Archipelago).—Part 5. *Mem. Proc. Manchester Lit. Phil. Soc.*, vol. lii, no. 13.

—— 1918. Report on the Recent Foraminifera dredged off the East Coast of Australia. H.M.S. *Dart*, Station 19. *J.R.M.S.*, 1918, pp. 1–25, pls. i, ii, pp. 121–53, pls. iii–v, pp. 249–64, pl. vi.

WALKER, G., & JACOB, E. 1798. In G. Adams: Essays on the Microscope. F. Kanmacher's (2nd) edn. (Plates copied from Walker and Boys: Testacea Minuta Rariora, &c., 1784, and named by E. Jacob.) London.

WILLIAMSON, W. C. 1858. On the Recent Foraminifera of Great Britain. London Ray Society).

EXPLANATION OF THE PLATES.

(Except where otherwise stated, *a* represents the superior aspect, *b* the ventral aspect, and *c*, the edge view.)

PLATE 8.

Figs. 1 *a*, *b*. *Spirillina decorata* Brady. Altona Bay Coal Shaft. *a*, side view; *b*, edge view. × 50.

2 *a*, *b*. *Spirillina vivipara* Ehrenberg. Kackeraboite Creek. *a*, side view; *b*, edge view. × 68.

3 *a*, *b*. *Spirillina pectinimarginata*, sp. n. Holotype. Kackeraboite Creek. *a*, side view; *b*, edge view. × 68.

4 *a*, *b*, *c*. *Spirillina inaequalis* Brady. Kackeraboite Creek. × 90.

5 *a*, *b*. *Spirillina limbata* Brady var. *tuberculolimbata* Chapman. Kackeraboite Creek. *a*, ventral aspect; *b*, edge view. × 90.

6 *a*, *b*. *Patellina corrugata* Williamson. Kackeraboite Creek. *a*, apical view; *b*, edge view. × 99.

7 *a*, *b*, *c*. *Discorbis globularis* (d'Orbigny). Grice's Creek. × 50.

8 *a*, *b*, *c*. *Discorbis opercularis* (d'Orb.). Kackeraboite Creek. Plastogamic examples. × 68.

9 *a*, *b*, *c*. *Discorbis tuberculata* (Balkwill & Wright) var. *australiensis*, nov. Holotype. Altona Bay Coal Shaft. × 68.

10 *a*, *b*, *c*. *Discorbis balcombensis*, sp. n. Holotype. Kackeraboite Creek. × 68.

11 *a*, *b*, *c*. *Heronallenia lingulata* (Burrows & Holland). Grice's Creek. × 36.

12 *a*, *b*, *c*. *Heronallenia wilsoni* (Heron-Allen & Earland). Kackeraboite Creek. × 68.

PLATE 9.

Figs. 13 *a*, *b*, *c*. *Discorbis bertheloti* (d'Orb.). Altona Bay Coal Shaft. × 28.

14 *a*, *b*, *c*. *Discorbis bertheloti* (d'Orb.) var. *papillata*, nov. Holotype. Kackeraboite Creek. × 50.

15 *a*, *b*, *c*. *Calcarina* sp. aff. *spengleri* (Linné). Balcombe Bay. × 25.

16 *a*, *b*, *c*. *Cibicides victoriensis*, sp. n. Kackeraboite Creek. × 25.

17 *a*, *b*, *c*. *Eponides concentricus* (Parker and Jones). Altona Bay Coal Shaft. × 25

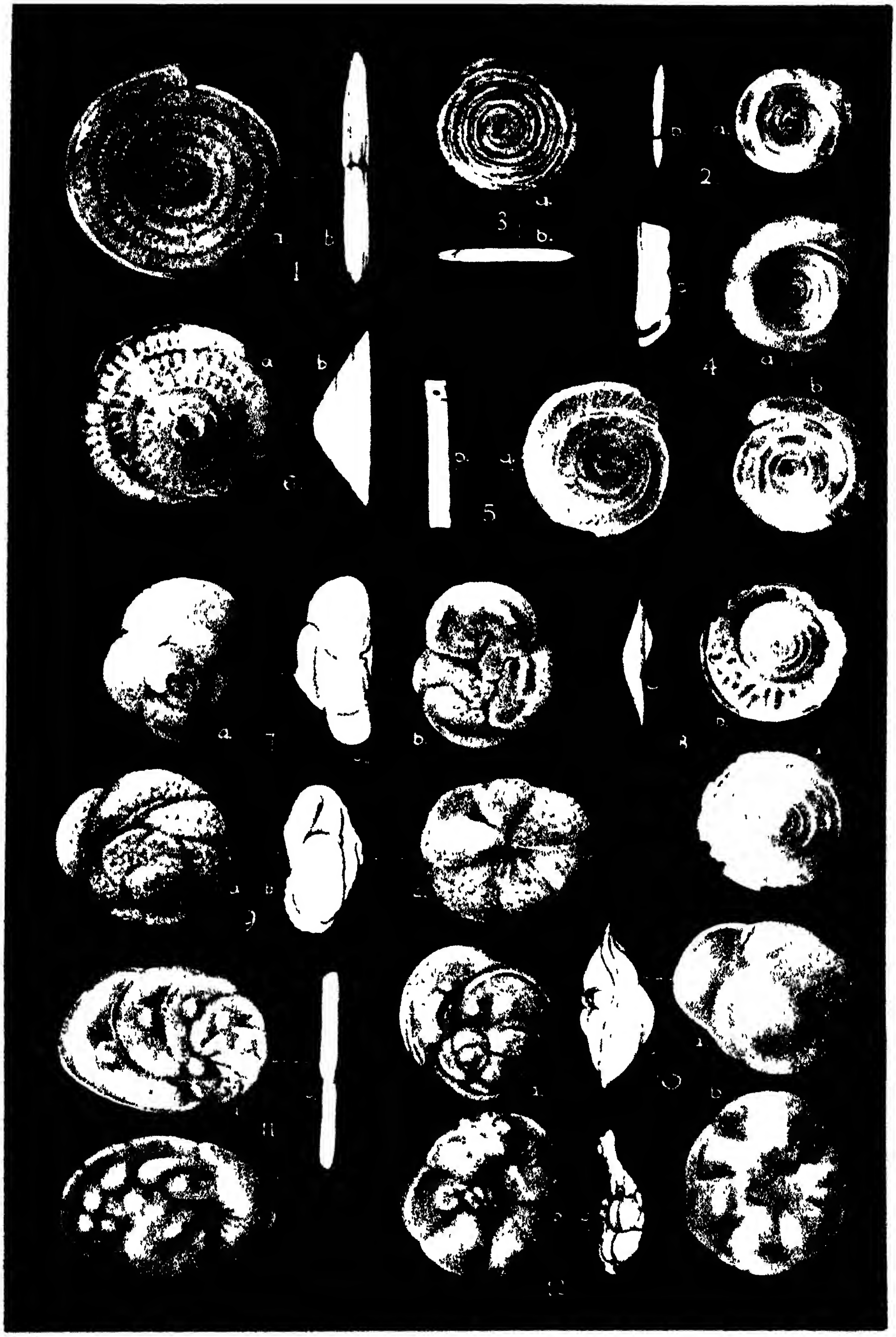
18 *a*, *b*, *c*. *Eponides repandus* (Fichtel and Moll). Altona Bay Coal Shaft. × 25.

19 *a*, *b*, *c*. (?) *Pulvinulinella tenuimarginata*, sp. n. Holotype. Kackeraboite Creek. × 50.

20 *a*, *b*, *c*. *Rotalia howchini*, sp. n. Holotype. Altona Bay Coal Shaft. × 25.

21 *a*, *b*, *c*. *Rotalia beccarii* (Linné). Altona Bay Coal Shaft. × 50.

22 *a*, *b*, *c*. *Epistomina elegans* (d'Orb.). Grice's Creek. × 25.



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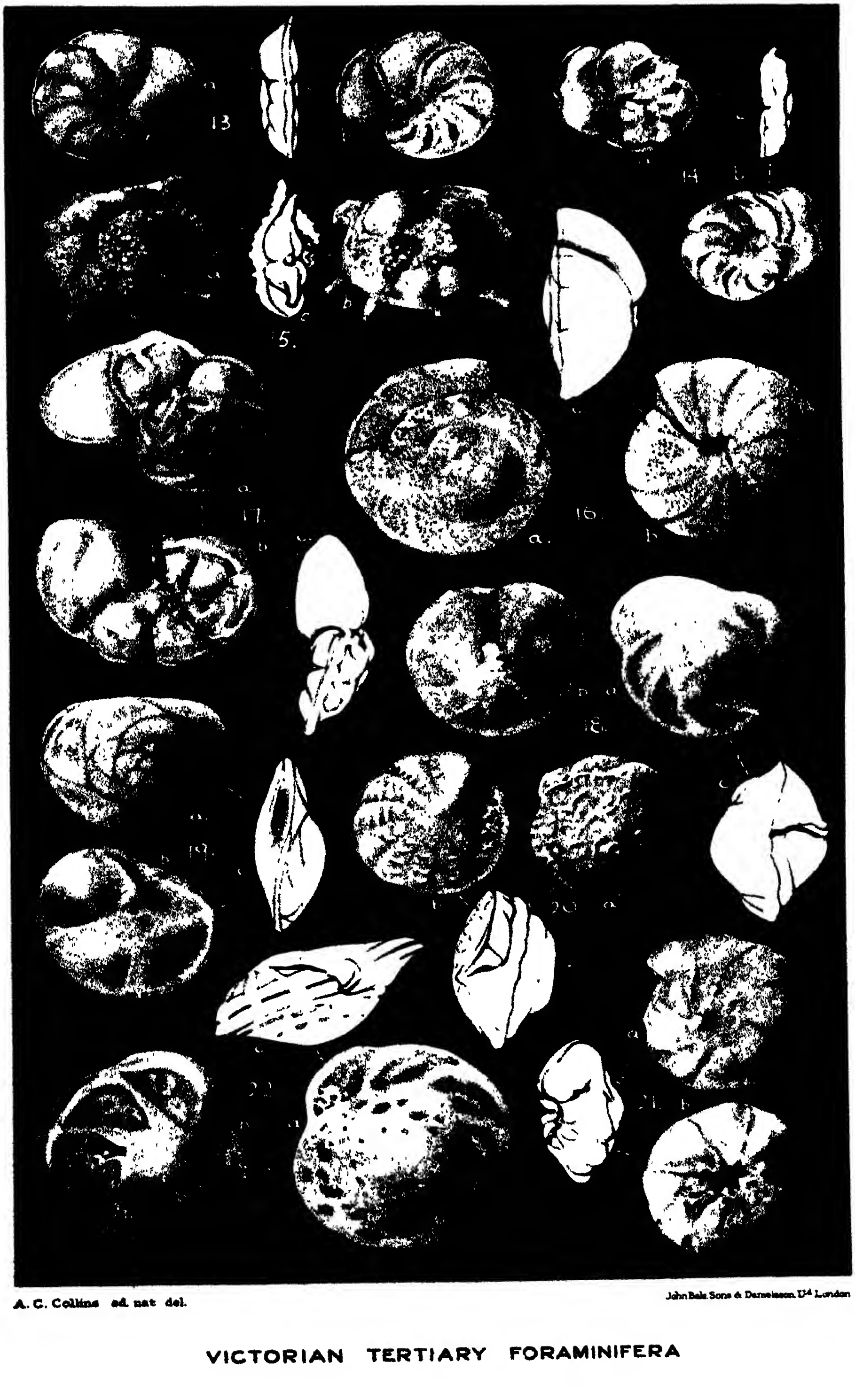

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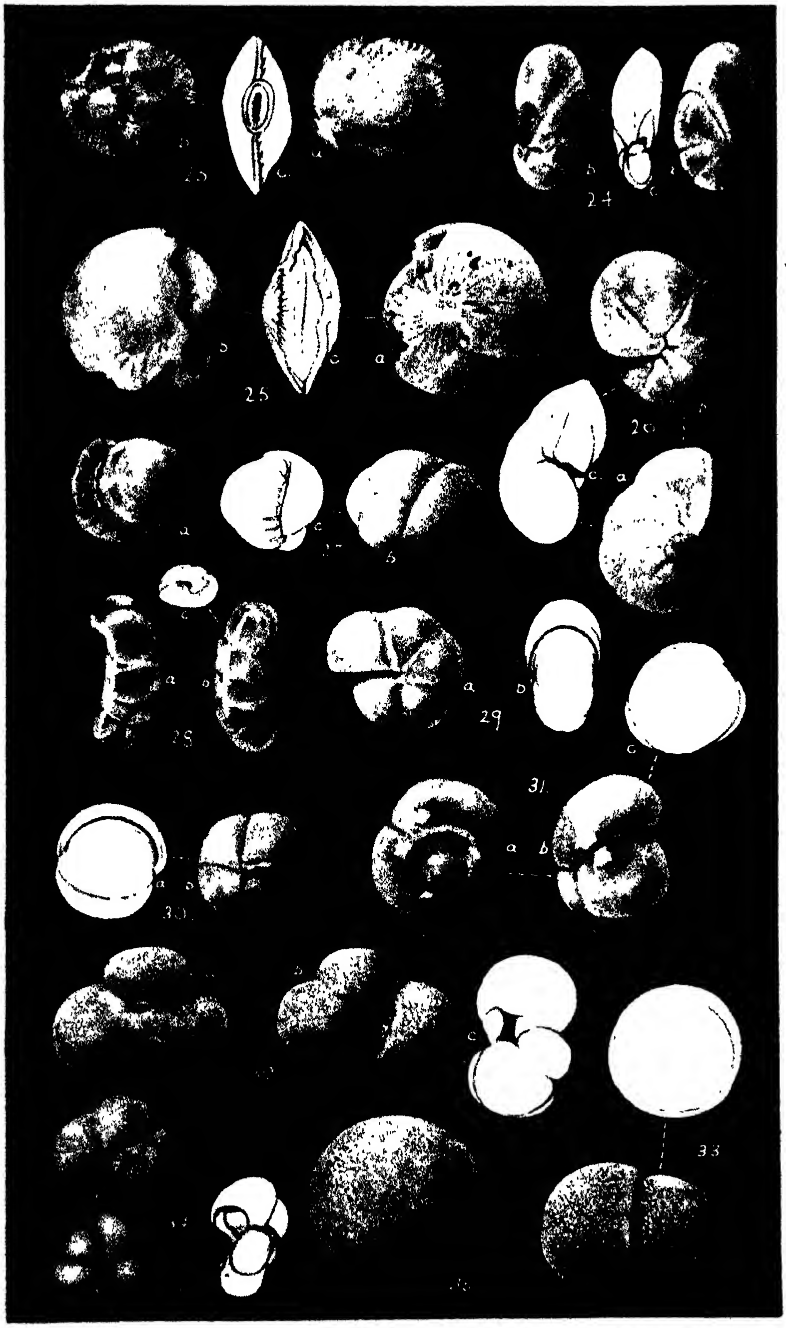

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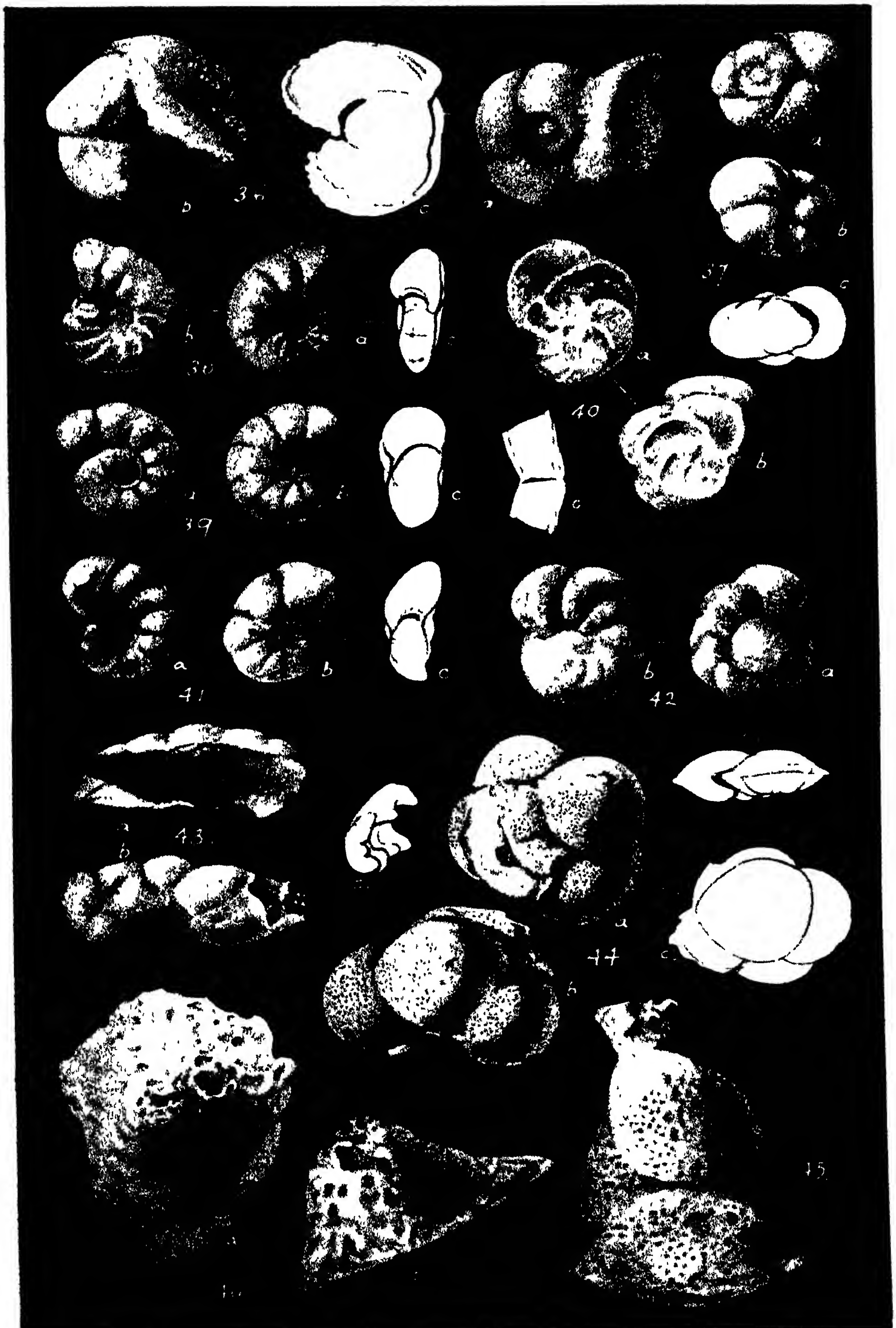

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VICTORIAN TERTIARY FORAMINIFERA

Plate 10.

Figs. 23 *a, b, c. Siphonina australis* Cushman. Altona Bay Coal Shaft. × 25.

24 *a, b, c. Cancris auricula* (Fichtel and Moll). Grice's Creek. × 25.

25 *a, b, c. Amphistegina lessonii* d'Orb. Balcombe Bay. *a, b*, side views; *c*, edge view. × 11.

26 *a, b, c. Ceratobulimina haueri* (d'Orb.) var. *australis* Cushman and Harris. Altona Bay Coal Shaft. × 50.

27 *a, b, c. Cassidulina delicata* Cushman. Grice's Creek. *a, b*, side views; *c*, edge view. × 68.

28 *a, b, c. Cassidulinoides chapmani* Parr. Altona Bay Coal Shaft. *a, b*, side views; *c*, end view. × 68.

29 *a, b. Pullenia quinqueloba* (Reuss). Kackeraboite Creek. *a*, side view; *b*, apertural aspect. × 50.

30 *a, b. Pullenia sphaeroides* (d'Orb.). Kackeraboite Creek. *a*, apertural view; *b*, side view. 50.

31 *a, b, c. Sphaeroidina bulloides* d'Orb. Kackeraboite Creek. *a*, ventral view; *b*, dorsal view; *c*, end view. × 50.

32 *a, b, c*; 34 *a, b, c. Globigerina bulloides* d'Orb. 32, Altona Bay Coal Shaft. 33, Grice's Creek. × 50.

33, 35. *Orbulina universa* d'Orb. 33, A two-chambered example. Altona Bay Coal Shaft. 35, Kackeraboite Creek. × 50.

Plate 11.

36 *a, b, c. Globorotalia dehiscens*, sp. n. Holotype. Kackeraboite Creek. × 50.

37 *a, b, c. Globorotalia scitula* (Brady). Grice's Creek. × 55.

38 *a, b, c. Anomalina rotula* d'Orbigny. Grice's Creek. × 25.

39 *a, b, c. Anomalina glabrata* Cushman. Kackeraboite Creek. × 25.

40 *a, b, c. Discorbis planoconcava* (Chapman, Parr, and Collins). Holotype. Kackeraboite Creek. × 68.

41 *a, b, c. Cibicides lobatulus* (Walker and Jacob). Grice's Creek. × 25.

42 *a, b, c. Cibicides ungerianus* (d'Orb.). Grice's Creek. × 25.

43 *a, b, c. Dyocibicides biserialis* Cushman and Valentine. Kackeraboite Creek. × 99.

44 *a, b, c. Carpenteria rotaliformis* Chapman and Crespin. Grice's Creek. *a*, dorsal aspect; *b, c*, side views. × 18.

45. *Carpenteria proteiformis* Goes. Altona Bay Coal Shaft. × 25.

46 *a, b. Polytrema miniaceum* (Pallas). Balcombe Bay. Two aspects. × 25.

Reports of the Cambridge Expedition to British Guiana, 1933. Illumination in the rain forest at ground level. By G. S. Carter, M.A., Ph.D., F.L.S.

(With 1 Text-figure)

[Read 18 January 1934]

Introduction.

The density of the shade at the ground level in the tropical forest is, perhaps, the most striking characteristic of the habitat. It is a condition which is of dominating importance in the oecology of the flora, and it is not unlikely that both the weakness of the light and the distribution of such light as there is over the spectrum may be of importance to the fauna.

This being so, it is not surprising that many biologists have made attempts to measure the light in the forest. Most of these measurements have been made with various forms of actinometer or illuminometer. These methods have several disadvantages. They do not readily give determinations of the intensity of the light in physical units, and knowledge of the actual strength of the light is required if comparisons are to be made with the light in other habitats; many of them measure light of certain wave-lengths rather than the total light; and, in most, subjective errors are large, as, for instance, in matching the equality of two illuminations, not always of the same colour.

Within the last few years, the development of the photo-electric cell has provided a method of measuring light by means of which most of these disadvantages are avoided. The cell gives measurements of the light in physical units, subjective errors are at a minimum, and the more recent forms of the apparatus are sensitive over the whole range of the visible spectrum and beyond it. In addition, these recent forms are free from the delicacy of the earlier types and are very portable.

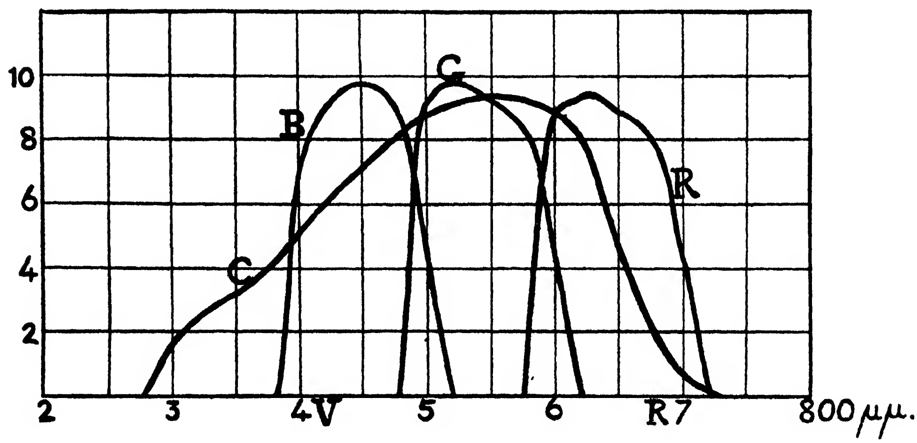
The measurements reported in this paper were made in certain types of rain forest in British Guiana during the visit of the Cambridge Expedition to that country in 1933. The expedition was mainly concerned with the study of the rivers and swamps of the forest area, and a Bernheim photo-electric cell was taken to Guiana with the primary object of measuring the penetration of light into these waters. But no measurements of the light in the rain forest had, so far as could be discovered, previously been made with a photo-electric cell, and therefore it seemed worth while to take some observations in the forest with the cell.

Methods.

The cell, being intended for use under water, was enclosed in a watertight case with a quartz window. Three filters (red, green, and blue) were used to differentiate light in different parts of the spectrum. It would clearly have been better if more filters with narrower ranges of transmitted light could have been used, but this was not possible. Even with these three filters, the light reaching the cell in the shade of the forest was often not far from the lower limit of the sensitivity of the cell. If more filters had been used, the transmitted light would have been too weak for accurate measurements.

The spectral sensitivity of the cell and the absorption curves of the filters are shown in the text figure.

Two objects were kept in view in making these observations. The illumination of the floor of the forest is very variable between places on the ground



Wave-lengths.

C. The spectral sensitivity of the Bernheim photo-electric cell.

R, B, G. Absorption curves for the three colour filters used with this cell.

The abscissae are expressed in arbitrary units.

within a few feet of each other. It is, thus, clearly of more importance to obtain values for the average illumination of the ground over considerable areas than to measure the illumination at a few selected spots. For this reason estimation of the average illumination of the forest floor was made the primary object of the observations. Secondly, it was desired to estimate separately the illumination in different parts of the spectrum.

It is by no means easy to obtain reliable determinations of the average illumination of the forest floor. We had with us only one cell, and therefore exactly contemporaneous observations could not be taken in the forest and in the open. In the forest areas of British Guiana usually about 50 per cent. of the sky is covered with cloud, and, even if the sun is unclouded, the intensity

of the sunlight varies, here as everywhere, from minute to minute. The observations given in this paper are undoubtedly subject to errors due to this cause. Again, the variation of the illumination of the ground is so large that an average value found for it cannot be of great accuracy. In this connexion difficulties arise not only from the variability of the density of the shade according as positions are taken near to or far from tree trunks and other objects, but also from the presence of small spots of sunlight on the ground. These ' sun flecks ' are always present in the forest, but they vary in size and number in different types of forest. Except where an opening has been made by a fallen tree, they are always small. The sunlight of these patches varies in strength with their size. It is never as bright as the full sunlight of a large clearing.

Under these circumstances, the following procedure was adopted. It was found possible to choose spots where the shade was of average density and sun flecks of average size, and therefore of average illumination. Readings were first taken in a large clearing as near as possible to the place in the forest where the light was to be measured, and these readings were used as giving the intensity of full sunlight at the time of the observations. Care was taken in making these observations that the cell was exposed to direct sunlight for as short a time as possible, for its sensitivity falls when its temperature rises above 30° C., which was close to the maximum shade temperature. After this, the instrument was moved as quickly as possible to a position in the forest where the shade was of average density, and another series of readings was taken. Thirdly, it was moved to a sun fleck of average size for the type of forest under investigation, and a third series of readings was taken. In each set of observations a new measurement of the total light was made after each reading with a filter, in order that any variation of the total light during a set of the observations might be observed. If such variations occurred, the readings were corrected for them, but these variations were always small. They did not exceed 1 per cent. of the total light in any of the observations which have been recorded.

Each set of observations is therefore true within narrow limits for a total light of the same intensity. On the other hand, the observations in the open and in the shade or sun flecks are subject, when compared, to the errors due to the variations in the intensity of the sunlight. Not more than a few minutes were allowed to elapse between the three sets of observations in one locality, and all the observations were made between 11 a.m. and 3 p.m., with the sun unclouded. These errors were thus kept at a minimum.

Lastly, the area of the sun flecks was estimated as a percentage of the total area of the ground, and the final estimate of the illumination was obtained by combining the observed intensities of the light in the shade and in the sun flecks in this proportion. Here, probably, the largest errors entered the determinations. The variation in the size of the sun flecks and in their illumination made it very difficult to estimate accurately the proportion of shade to sun fleck on the ground.

TABLE I.

	1. Low secondary forest.			2. Creek Mora forest.			3. High Mora forest, I.			4. High Mora forest, II.			5. Mixed forest, I.		
	a. Ergs. $\times 10^7$.	*b.* Per cent.	*c.* Per cent.	*a.* Ergs. $\times 10^7$.	*b.* Per cent.	*c.* Per cent.	*a.* Ergs. $\times 10^7$.	*b.* Per cent.	*c.* Per cent.	*a.* Ergs. $\times 10^7$.	*b.* Per cent.	*c.* Per cent.	*a.* Ergs. $\times 10^7$.	*b.* Per cent.	*c.* Per cent.
Open.															
No filter ...	5·7	100	.	5·7	100	.	6·3	100	.	8·8	100		6·37	100	..
Red filter	3·35	60	.	3·35	60	.	4·4	70	..	4·8	55		4·2	t6	
Green filter	0·92	16		0·92	16		1·06	17	..	1·4	16		0·88	14	
Blue filter	1·07	19	.	1·07	19	..	1·28	20	..	1·6	18		1·06	17	.
Shade.	$\times 10^5$.			$\times 10^5$.			$\times 10^5$.			$\times 10^5$.			$\times 10^5$.		
No filter ...	5·03	100	0·88	2·03	100	0·36	2·55	100	0·40	1·7	100	0·18	2·67	100	0·42
Red filter ...	3·05	61	0·90	0·89	44	0·27	1·55	61	0·35	0·78	46	0·16	1·48	56	0·35
Green filter	1·00	20	1·09	0·39	19	0·42	0·38	16	0·36	0·25	15	0·18	0·36	13	0·41
Blue filter ..	1·27	25	1·20	0·55	27	0·52	0·48	19	0·38	0·29	17	0·18	0·44	16	0·41
Sun fleck.	$\times 10^7$.			$\times 10^7$.			$\times 10^7$.			$\times 10^7$.			$\times 10^7$.		
No filter ...	4·15	100	73	0·59	100	10·4	3·07	100	49	2·1	100	21	4·6	100	72
Red filter ...	2·12	51	63	0·33	56	10·0	1·59	52	36	1·13	54	24	2·6	57	62
Green filter ...	0·63	15	68	0·10	16	10·9	0·53	17	50	0·35	17	25	0·64	16	73
Blue filter	0·77	18	72	0·13	22	12 1	0·63	21	49	0·44	21	27	0·76	17	72
Area of Sun flecks ...	...	..	5	..		0·5	...		1			1	..		2
Illumination.															
No filter	...	..	4·57	..		0·41	.		0·89		...	0·42	..	...	1·86
Red filter ...	...	..	4·05	..		0·32	.		0·71		.	0·40		.	1·59
Green filter ...	.	.	4·49	...	.	0·47	.		0·86			0·43	.	...	1·87
Blue filter ...	..		4·80	.		0·58	.		0·87		.	0·45	.	...	1·85

Table I (*continued*).

	6. Mixed forest, II.			7. Mora forest with greenheart.			8. Manicole swamp.			9. Wallaba forest.		
	a. Ergs. $\times 10^7$.	*b.* Per cent.	*c.* Per cent.	*a.* Ergs. $\times 10^7$.	*b.* Per cent.	*c.* Per cent.	*a.* Ergs. $\times 10^7$.	*b.* Per cent.	*c.* Per cent.	*a.* Ergs. $\times 10^7$.	*b.* Per cent.	*c.* Per cent.
Open.												
No filter	4·9	100		5·6	100		2·9	100		2·75	100	
Red filter	3·28	67		3·9	70		2·23	77		1·81	66	
Green filter	0·97	20		1·3	23		0·58	20		0 45	16	
Blue filter	1·50	31		1·9	34		0·79	27		0·54	20	
Shade.	$\times 10^5$.			$\times 10^5$.			$\times 10^5$.			$\times 10^5$.		
No filter	1 5	100	0 31	2·2	100	0·39	2·39	100	0·82	2·2	100	0·80
Red filter	0·90	60	0·28	1·3	59	0·33	1·24	52	0·56	1·31	60	0·73
Green filter	0·29	19	0 30	0·44	20	0·32	0·64	27	1·10	0·37	17	0·82
Blue filter	0·42	28	0·28	0·69	31	0·36	0·84	35	1·06	0 40	18	0·74
Sun fleck.	$\times 10^7$.			$\times 10^7$.			$\times 10^7$.			$\times 10^7$.		
No filter	2·65	100	54	1·35	100	24	0 365	100	13	1·07	100	39
Red filter	1·70	64	52	0·84	62	22	0·165	45	7·4	0·52	49	29
Green filter	0·52	19	54	0·28	21	22	0·066	18	11	0·19	18	42
Blue filter	0 72	27	48	0·44	33	23	0·107	29	13	0·23	21	43
Area of Sun flecks			1			1			3			2·5
Illumination.												
No filter			0·85			0 63			1 21			1·77
Red filter			0·80			0·55			0·78			1·45
Green filter			0·84			0·54			1·13			1·87
Blue filter			0·76			0·59			1·45			1·81

Notes:—Column *a.* Light in ergs per sq. cm. per sec.
,, *b.* Light as percentages of the total light at the place of observation.
,, *c.* Light as percentages of the light of the same wave-length in the open

The illumination is calculated from the higher figures of column *c*, and expressed as percentages of the light of the same wave-length in the open.

Results.

In Table I (pp. 582–3) the results of nine sets of observations in different types of forest are given. The direct readings of the instrument have been corrected for the variation of its sensitivity in different parts of the spectrum and for the variation in the transmission of the filters. The figures given in the columns headed *a*, therefore, give comparable measurements of the energy of the light. In the columns headed *b* the same figures are expressed as percentages of the total light in the position of observation, and in those headed *c* they are expressed as percentages of the light of the same wave-length in the open, i.e. of the figures at the top of the columns *a*. At the bottom of the table, estimates of the illumination of the forest floor, calculated by the method just described, are given. These are expressed as percentages of the light of the same wave-lengths in the open.

Table II.

	1. Low secondary forest.	2. Creek Mora forest.	3. High Mora forest, I.	4. High Mora forest, II.	5. Mixed forest, I.
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
No filter	100	100	100	100	100
Red filter . . .	54	46	56	50	62
Green filter	17	20	16	16	14
Blue filter .	20	17	20	19	17

	6. Mixed forest, II.	7. Mora forest with greenheart.	8. Manicole swamp.	9. Wallaba forest.
	Per cent.	Per cent.	Per cent.	Per cent.
No filter	100	100	100	100
Red filter ...	62	60	50	53
Green filter	19	20	24	17
Blue filter	27	32	33	20

In Table II the final estimates of the illumination in Table I are expressed as percentages of the total light on the floor of the forest.

Types of forest in which the light was measured.

In the following notes the character of the various types of forest in which these measurements were made is described :—

1. *Low secondary forest.* Here a fire had burnt the forest about five years before our visit. At the time of our observations the ground was covered with low forest, which reached a height of 30–40 feet. The undergrowth was very thick. A few trees had survived the fire and were standing to a height

of 100 feet, but there was no continuous canopy at that height. In the absence of a canopy the sun flecks were large and numerous.

2. *Creek Mora forest.* These observations—and all those given in the table except the first set—were made in undisturbed forest. The forest in which this set of observations was made covered a swamp near the banks of a flowing stream or 'creek'. At most times there was 1–2 feet of water over the ground between the trunks of the trees. The forest was extremely dark, and vegetation at the ground level very slight. There were hardly any aquatic plants in the water, and above the surface only a few Marantaceae and similar plants. Very few saplings of the high trees were to be seen. Mora (*Mora excelsa* Bth.) was the most numerous tree, but palms and other trees were also present.

3, 4. *Mora forest.* Along the banks of the Cuyuni, where these observations were made, this type of forest covers large areas of low and damp ground near the river. Mora is the dominant tree, forming a dense canopy at a height of about 100 ft. The undergrowth is thin but variable, consisting chiefly of thin-stemmed saplings of the high trees. Some lower trees and shrubs are also present. The forest is always dark, but its darkness is variable. The third and fourth sets of the observations were taken respectively in the lighter and darker parts of this forest.

5, 6. *Mixed forest.* This forest is found on somewhat higher ground than the Mora forest. Mora is present, but in smaller numbers, and many other trees occur. There is a dense canopy at about the same height as in the Mora forest. The undergrowth is very variable, being sometimes as thin as in the Mora forest and sometimes much thicker. The fifth set of observations was taken in a place where the undergrowth was thick, the sixth set where it was thinner.

7. *Mora forest with greenheart.* This variety of Mora forest was found on dry ground near the banks of the river. Greenheart (*Ocotea Rodioei* (Schomb.) Mez.) was plentiful. The undergrowth was very similar to that in typical Mora forest.

8. *Manicole swamp.* This swamp lay in a depression, 200–300 yards across, on the top of a ridge of high ground. It was apparently without any outlet to the river. The manicole palm (*Euterpe edulis* Mart.) was the dominant tree, but there was a considerable proportion of other trees. Plants growing above the surface of the water were numerous. Among these *Rapatea paludosa* Aubl. was frequent, and there were many Marantaceae. There was little aquatic vegetation.

9. *Wallaba forest.* In the Cuyuni district, this forest is found at some distance from the river on high ground. Wallaba (*Eperua falcata* Aubl. and other spp.) is dominant, but many other trees occur. The undergrowth is much thicker than in Mora forest. The trees form a moderately thick canopy at about 100 feet.

Further information concerning these types of forest can be found in the paper by Davis and Richards (1933).

The accuracy of the determinations.

It is not easy to estimate the size of the probable errors in these determinations. The errors are undoubtedly large.

The error in the corrected readings of the instrument (columns *a* of Table I) varies with the intensity of the light. It has been stated that the weakest lights were not far from the limit of the sensitivity of the instrument, and the error is therefore greatest where the light is weakest, i.e., in the measurements in the shade. Here the probable error is, perhaps, 5 per cent. of the observed values.

Where the determinations of a single set of observations are compared among themselves, the error is not greatly increased, since all the determinations of each set have been adjusted to the same total light. The results of the columns *b* are of this type, and their probable error is therefore not much greater than 5 per cent.

It has been stated that some variation must be assumed in the strength of the sunlight at the times when the observations were taken in the open and in the shade or sun flecks. The size of this variation may be taken to be about 10 per cent. of the total light. This error enters into the figures of the columns *c*, which must therefore have a larger error than this. It is, perhaps, justifiable to assume a probable error of 15 per cent. in these figures. In the figures for the illumination given at the bottom of the table, errors due to inaccurate estimation of the area of the sun flecks also enter. The probable error in these figures must be at least 25 per cent., and in the better illuminated positions, where most of the light is contained in the sun flecks, the error may be as large as 50 per cent.

Where the members of each set of figures for the illumination are compared among themselves, this last type of error is largely avoided, and the error due to variation in the strength of the sunlight is also much less. For these reasons the errors in the figures of Table II are probably not more than 10 per cent.

It may be thought that these probable errors, especially those of the figures for the illumination of the ground, are very large. But it must be remembered that the illumination is very variable over small areas of the ground. Probably its proportionate variation is much greater even than the 50 per cent. which is given as the maximum probable error of these determinations. It is doubtful whether greater accuracy in the determinations would largely increase their value.

Discussion.

The figures given in Table I show illuminations in undisturbed forest varying from about 2 per cent. to less than 0·5 per cent. and values for the shade light varying from 0·8 to 0·2 per cent. These results are in approximate agreement with the estimates of the light in tropical forests which have been previously published. Burkill (1911) found a minimum illumination of 1/400 of sunlight in rain forests in the Himalayan region. Allee (1927) measured the light in

the shade in the rain forests of Panama and gives an estimate of 1/442 of sunlight for the shade light—not the average illumination at ground level. Davis and Richards (1933) found values between 1·6 and 0·55 per cent. for the illumination in the Guiana forest. All these results were obtained with actinometers or illuminometers.

If the results of Table I are compared with the descriptions of the vegetation in the different types of forest which have been given, it will be found that the growth of the vegetation at ground level is in agreement with the illumination in that position. There is also approximate agreement between the results here given for the different types of forest and those which Davis and Richards (1933) have given. Their results differ most considerably from those given here in the determinations of the light in the Mora forest, where they found an illumination of 1·33 per cent.—greater than that in the Mixed forest. The average of the figures given in Table I is 0·65 per cent., which is lower than either of the determinations in the Mixed forest. This disagreement is probably due to differences in the type of Mora forest investigated on the two occasions. On the banks of the Cuyuni the Mora forest is clearly very dark, even to direct observation, and its undergrowth is thin. Palms are rare, and herbaceous vegetation very scanty. In these respects this forest differs from the Mora forest described by Davis and Richards (1933, Part II). From their description it seems probable that the Mora forest in which their observations were made was intermediate between the Mora forest of the observations of this paper and the Manicole swamp. If this were so, their figures for the illumination would be more nearly in agreement with the figures given here.

In the Mixed forest Davis and Richards' estimations of the light are somewhat lower than the figures given in the table for the darker example of this forest. It has been noted that this type of forest is very variable, and it seems probable that they were working in a variety of Mixed forest as dark or darker than the darker Mixed forest of the observations of this paper.

On the whole, the agreement between the results given by Davis and Richards and those given here is as good as could be expected in the circumstances of the observations.

In England the shade of dense deciduous woods has been found to be in the neighbourhood of 1 per cent. of sunlight (Salisbury, 1916; Adamson, 1921). In America Shelford and Kunz (1929) found similar or rather higher values, using photo-electric cells. The full sunlight of British Guiana has about 1·5 times the strength of sunlight in this country. The actual intensity of the light in the woods of the two countries is, therefore, not very different.

The figures of Table II, when compared with those for the light in the open in Table I, show a reduced percentage of red light in the shade of the forest. The average reduction in the nine determinations is about 20 per cent. of the red light present. This is considerably greater than the error to be expected in the average of these determinations, and the reduction must be considered real.

Since only three filters were used to divide the spectrum, variations in the intensity of the light would escape detection in the results, if they were restricted to narrow bands of the spectrum. It is probable that such variations occur in the light of the forest shade. Some of this light must have passed through the leaves of the overhanging canopy, and would show reduction in the absorption bands of the chlorophyll spectrum, many of which are narrow. The results give no evidence of variations in the spectral distribution of the light except at the red end of the spectrum. Presumably, the methods employed were not accurate enough to show variations in other parts of the spectrum.

The conclusion that there is proportionately less red light in the forest shade than in full sunlight is probably not in real conflict with the results of McClean (1919), who measured the intensity of the light of various wave-lengths reflected from leaves, and found that a *greater* proportion of red light was reflected. The results in the forest shade should only be similar to his if most of the shade light were reflected from the leaves of the canopy, and not transmitted through them. In dense shade of the forest it seems unlikely that much of the light has been reflected. When one looks up from the ground in a place where the canopy is thick and leaf growth below it scanty, the impression is that of a green ceiling with small openings through which the sky can be seen. If much of the light were reflected from the leaves of the canopy, one should rather get the impression, on looking up, of scattered bright patches of light where strongly illuminated leaves were reflecting it. On the other hand, in any opening in the forest, it is probable that much of the light at the ground level has been reflected from the leaves of the trees which form walls of vegetation around any such open space. The photographs given by Karsten (1924) seem rather to be of openings in the forest than of the dark interior, and this may account for his conclusion that much of the light at the ground level in the forest has been reflected from leaves. But with the conditions in such positions we are not concerned.

It is clear that the reduction of 20 per cent. in the red light does not give a measure of the reduced efficiency of the light for photosynthesis. The reduction must occur mostly in the absorption-bands of the chlorophyll-spectrum, and in these bands the reduction must be greater than 20 per cent. Thus, the photosynthetic efficiency must be reduced by considerably more than 20 per cent., and therefore, for the plants, the density of the shade is considerably greater than the figures which have been given for the illumination imply.

Some attempt was made to measure the proportionate amount of ultra-violet light in the shade of the forest, and to compare it with that in sunlight. These attempts were made by the use of a filter which cut out all light of shorter wave-length than 400 μ. The results were not satisfactory, but they gave no indication of any large alteration in the proportion of ultra-violet light.

The reduction of 20 per cent. in the red light is not large, and probably not large enough to be of any great importance to the fauna of the forest floor. Shelford and Kunz (1929) measured the light in different parts of the spectrum

in the shade of American woods. In deciduous woods they found a slight excess in the yellow and a reduction in the red; in pine-woods they found a very much greater excess in the yellow. The light in the tropical forest is, in its spectral distribution, much more like that in deciduous woods in temperate countries than that in pine-woods.

I am indebted to Mr. T. G. Tutin of Downing College and to Mr. P. W. Richards of Trinity College, Cambridge, for much help in the preparation of this paper.

SUMMARY.

1. The intensity of the light at the ground level in the rain forests of British Guiana was measured by means of a Bernheim photo-electric cell. It was found that the shade light in different types of undisturbed forest lies between 0·8 and 0·2 per cent. of sunlight; and that the illumination of the ground, which is lighted by sun flecks as well as by the shade light, lies between 2 and 0·4 per cent of sunlight.

2. A proportionate reduction of 20 per cent. in the light at the red end of the spectrum was found in the illumination of the forest floor.

REFERENCES.

ADAMSON, R. S. 1921. *J. Ecol.*, ix, 114.
ALLEE, W. C. 1927. *Ecol.*, vii, 273.
BURKILL, I. H. 1922 *Rep. Bot. Surv India*, x, 1.
DAVIS, T. A. W., & RICHARDS, P W. 1933. Part I, *J. Ecol.*, xxi, 350; Part II, *in the press.*
KARSTEN, G. 1924. *Vegetationsbilder*, xvi, Hft. 3.
MCCLEAN, R. C. 1919. *J. Ecol.*, vii, 121.
SALISBURY, E. J. 1916. Ibid., iv, 83.
SHELFORD, V. E., & KUNZ, J. 1929. *Ecol.*, x, 298.

Entomological Expedition to Abyssinia, 1926–7: Orthoptera of the families Mantidae, Gryllidae, Tettigoniidae, and Acrididae. By B. P. Uvarov. (Communicated by Dr. Hugh Scott, F.L.S.)

(With 10 Text-figures)

[Read 1 February 1934]

The chief interest of the present collection, made by Dr. H. Scott and Mr. J. Omer-Cooper, lies in the fact that, so far, very little information was available with regard to the Orthoptera living at high elevations in the Abyssinian mountains. It appeared particularly interesting to investigate whether any faunistic elements can be found there, which may be regarded as northern, i.e., Palaearctic, in their origin.

The collection is sufficiently rich to be considered representative of the fauna, and the conclusions based on it will be probably found applicable not only to the region actually explored, but to all the highlands of Central Abyssinia.

In the following analysis of the fauna I will discuss the presence of representatives of various component groups of the Palaearctic fauna *.

The most northern elements of the Palaearctic fauna belong to the, so-called, Angara group, derived mainly from eastern Siberia and northern China. Such elements are typical of the subalpine fauna of mountains in the south of the Palaearctic Region, penetrating even to the Moroccan Atlas, but there is no trace of them in Abyssinia.

The next group is the Atlantic, more usually called Mediterranean. If one were to judge merely from the present distribution, at least three of the Abyssinian Orthoptera might be referred here. They are *Phaneroptera nana*, *Calephorus compressicornis*, and *Aiolopus thalassinus*. However, the first and the last are very widely distributed in Africa, and are clearly not at home in the Mediterranean subregion. As regards *Calephorus compressicornis*, this is a member of the fauna living amongst reeds and similar vegetation on the shores of rivers and lakes in the dry savanna-belt of Africa. The occurrence of a single species in the south of the Mediterranean region is, therefore, only a proof of the former extension of the savanna fauna, while its presence in Abyssinia is perfectly natural. All three species, therefore, are not indicative of an affinity between the Abyssinian and the Palaearctic faunas..

* See my paper on the composition of the Palaearctic fauna of Orthoptera in X^{e} Congr. Intern. Zool., Budapest, pp. 1516–24.

The Palaearctic Eremian element is represented in the collection by *Sphingonotus rubescens*. This is an insect both very common and widely spread in the Palaearctic deserts. It obviously penetrates into the mountainous parts of Abyssinia along river valleys, ascending up to 5500 ft. It is absent at the greater altitudes where the influence of semi-desert climate is not felt.

It will be seen, therefore, that there is no trace of Palaearctic influence in the Orthopterous mountain-fauna of Central Abyssinia.

This fauna, on the other hand, shows an unmistakable affinity with the fauna of Africa, and particularly of the eastern parts of the continent. The majority of the species are more or less widely distributed in Africa, and only at high altitudes a considerable admixture of endemic elements is observed. These endemic elements deserve a closer analysis, as follows :—

Polyspilota montana. Belongs to a purely Ethiopian genus, and does not differ greatly from its relatives.

Peropyrrhicia scotti } One species of this genus is known from Somaliland,
,, *cooperi* } and one, doubtfully belonging here, from Abyssinia. Allied genera of brachypterous Phaneropterinae are known from Meru (*Monticolaria*) and Ruwenzori (*Atlasacris*).

Phlesirtes brachiatus. Originally described from an unknown locality in British East Africa. Other species are known from Meru and Kilimanjaro.

Spalacomimus inermis. The only other species of the genus is from East Africa.

Paracomacris abyssinicus. Species of this genus are probably the commonest grasshoppers in African grasslands. In the mountains, brachypterous species occur, such as *P. elgonensis* Uv. and *P. loveni* Sjöst. on Mt. Elgon and the present species.

Oedaleus cephalotes. A genus typical of dry savannas of Africa.

Gastrimargus rothschildi montanus. A diminutive subalpine species of a lowland species.

Heteropternis minuta. The genus is well represented in African savannas. The present species is remarkable for its small size.

Parasphena montana } The genus is African and most of its species are
,, *abyssinica* } known from other mountains, such as Elgon and Kilimanjaro.

Neritius ? abyssinicus. The nearest relative of this species is *N. rothschildi*, known from southern Abyssinia.

Cataloipus pulcher abyssinicus. The typical form is known from East Africa, and the present subspecies differs from it mainly in the small size.

It will be seen from this list that all the endemic species of the Abyssinian highlands represent probably very recent offshoots of their relatives distributed in Africa, mainly in the savanna-areas. The subalpine fauna of Abyssinia is,

accordingly, very similar to that inhabiting other high mountains of Africa, though the actual species are different. They all have common roots in the lowland fauna, but the isolation resulted in the development of distinct species.

The examples of *Gastrimargus rothschildi montanus* and *Cataloipus pulcher abyssinicus* show us the trend in the development of the highland species from the lowland ones. It consists in the reduction in size and in the abbreviation of the organs of flight, so that the majority of the subalpine species are relatively small and flightless, or at least brachypterous.

The section on Gryllidae has been drawn up by Monsieur L. Chopard, and is inserted in the proper systematic position under his name.

I am greatly obliged to Dr. Hugh Scott for the privilege of working out this interesting collection

Localities.—An alphabetic list explaining the position of the localities was published in a paper entitled " Hymenoptera, III " of this series, in Ann. & Mag. Nat. Hist. (10) xii, pp. 99, 100, July 1933; and outline maps of the area of the Expedition appeared in a paper on " The distribution and habits of Culicidae in Central Abyssinia," in Bull. Ent. Res. xviii, pp. 84, 85, September 1927.

MANTIDAE *.

OXYOTHESPIS BREVICOLLIS Beier, Ann. & Mag. Nat. Hist. (10) vi, p. 450, 1930.

Loc. South-east of Lake Zwai, ca. 5500 ft., 10–13. xi, 2 ♂♂ (*Omer-Cooper*).

MIOMANTIS FALLAX Giglio-Tos.

Loc. Jem-Jem Forest, ca. 8000 ft., 25–29. ix, 1 ♂; same locality, 4–10. x, 1 ♂, " at candle light in house "; plains north of Lake Zwai, 5500–6000 ft., 3–4. xi, 1 ♂; Mt. Zuquala, Wambar Mariam, ca. 7000 ft., 28. x, 2 ♂♂, " from dry grass "; Mt. Chillalo, ca. 8000 ft., 6–8. xi, 3 ♂♂ (*Scott*); between Hawash River and Addas, 6000–7000 ft., 28–30. xi, 3 ♂♂, 1 ♀ (*Omer-Cooper*).

A fairly widely distributed East African species.

POLYSPILOTA MONTANA Beier, Ann. & Mag. Nat. Hist. (10) vii, p. 360, 1931.

Loc. Jem-Jem Forest, ca. 8000 ft., 6. x, 1 ♀ (*Scott*).

PSEUDOHARPAX ABYSSINICUS Beier, Ann. & Mag. Nat. Hist (10) vi, p. 457, 1930.

Loc. Plains north of Lake Zwai, 5500–6000 ft., 3–4. xi, 1 ♂ (*Scott*).

GRYLLIDAE. (By L. CHOPARD.)

GRYLLOTALPINAE.

GRYLLOTALPA AFRICANA (Beauv.).

Loc. Addas, Lake Hora Harsadi, ca. 7000 ft., 4. xii, 1 ♂ (*Scott*).

* Kindly determined by Dr. Max Beier (Vienna).

TRIDACTYLINAE.

TRIDACTYLUS VARIEGATUS Latr.

Loc. Hawash River, west of Mt. Zuquala, at ca. 6000 ft., 28. xi, 1 ♂ (*Omer-Cooper*).

GRYLLINAE.

LIOGRYLLUS MORIO (F.).

Loc. Jem-Jem Forest, ca. 8000 ft., 27–29. ix, 1 ♀ (*Omer-Cooper*).

GRYLLUS BRUNNERI Selys.

Loc. Addas, shore of Hora Harsadi, 3. xii, 1 ♀ (*Omer-Cooper*); between Addis Alam and Jem-Jem, 7000–8000 ft., under stones near Berga River, 20. ix, 1 ♂ (*Scott*).

GRYLLUS BURDIGALENSIS Latr.

Loc. Hawash railway-station, ca. 3500 ft., 2. ix, 2 ♂♂, 1 ♀ (*Omer-Cooper*); Jem-Jem Forest, ca. 8000 ft., 17–29. ix, 1 micropterous ♀ (*geminus* Serv.) (*Omer-Cooper*).

The three specimens from Hawash belong to the macropterous form (*cerisyi* Serv.). The male presents a rather peculiar coloration, with entirely brown forehead and one only light band between the eyes on the occiput.

GRYLLUS CONFIRMATUS Walk. (*consobrinus* Sauss.).

Loc. Muger valley, ca. 5500 ft., under stones in river-bed, 28–29. xii, 1 ♀ (*Scott*).

GRYLLUS CONSPERSUS Sch.

Loc. Hawash railway-station, ca. 3500 ft., 2. ix, 1 ♂ (*Omer-Cooper*).

SCAPSIPEDUS MARGINATUS Afz. & B.

Loc. Hawash railway-station, ca. 3500 ft., 2. ix, 2 ♀♀ (*Omer-Cooper*).

NEMOBIINAE.

PTERONEMOBIUS FASCIPES Walk.

Loc. River south-west of Mt. Zuquala, ca. 6000 ft., 31. x, 1 ♂, 1 ♀ (*Omer-Cooper*).

This is the first record in Africa of this species, widely distributed in tropical Asia. The specimens here recorded present no differences from those of India and Malaysia sufficient even to be considered as constituting a local form.

TRIGONIDIINAE.

TRIGONIDIUM CICINDELOIDES Ramb.

Loc. Marsh near Lake Hora Abjata, ca. 5000 ft., 18. xi, 2 ♂♂, 1 ♀ (*Omer-Cooper*); Jem-Jem Forest, 8000–9000 ft., ix–x, 5 ♂♂, 1 ♀ (*Scott*).

TRIGONIDIUM SIMIOLUS Karsch.

Loc. Marsh near Lake Hora Abjata, ca. 5000 ft., 18. xi, 1 ♂ (*Omer-Cooper*).
This species may be merely a macropterous form of the preceding one.

OECANTHINAE.

OECANTHUS RUFOPICTUS Chop., Stylops, i, p. 246, 1932.

Loc. North of Mt. Chillalo, Boru stream, ca. 7500 ft., 29. xi, 1 ♂ (*Scott*).

OECANTHUS SIMILIS Chop., *l. c.*, p. 246.

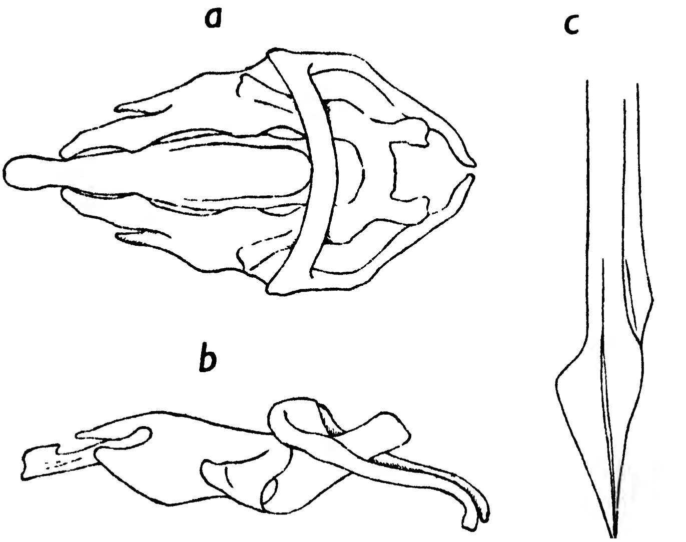
Loc. Above the Muger valley, ca. 8000 ft., 18–23. xii, 1 ♂, 1 ♀ (*Scott*); Wambar Mariam, Mt. Zuquala, ca. 7000 ft., 28. x, 1 ♀ (*Scott*).

PHALANGOPSINAE.

HOMOEOGRYLLUS RETICULATUS (F.).

Loc. Hawash railway-station, ca. 3500 ft., 2. ix, 1 ♂ (*Omer-Cooper*); Addas, shore of Hora Harsadi, 3. xii, 1 ♀ (*Omer-Cooper*).

TEXT-FIG. 1.



Speluncacris pilipennis, sp. n. (Chopard).
a, genitalia of male, ventral view; *b*, id., side view; *c*, apex of ovipositor of female.

SPELUNCACRIS PILIPENNIS Chop., sp. n. (Text-fig. 1.)

Loc. Between Jem-Jem and Wouramboulchi, 8000–9000 ft., 30. ix, 1 ♂ (*Omer-Cooper*); Jem-Jem Forest, ca. 8000 ft., 29. ix, 2 ♀♀ (*Scott*).

♂.—Size medium. Colour testaceous, varied with brown. Head small, with very short forehead; frontal rostrum a little narrower than the first antennal joint; face yellowish with a brown spot beneath each eye and a brown band on the facial shield. Palpi yellowish, with 3rd and 4th joints equal in length, the 5th a little longer, slightly enlarged at apex. Antennae brown, pubescent.

Pronotum very transverse, strongly narrowing in front; disc testaceous, varied with brown, embossed; lateral lobes brownish with a yellowish spot on the anterior angle, their inferior margin ascending backwards. Abdomen yellowish above and beneath, brown on the sides. Genitalia formed of a median piece with two lateral furcate lobes.

Legs yellowish, varied with brown. Anterior femora not serrulate beneath, presenting two brown rings near the apex; tibiae without any perforation, relatively short, armed with a few spinuliform bristles along the inferior margins, and presenting two inferior, subequal, apical spurs; metatarsi very long. Middle legs similar to the anterior ones, but a little longer. Posterior femora rather thick, with apical filiform part very short; their external face striated with brown; two brown rings near the apex; tibiæ a little longer than the femora, their upper margins serrulate and bearing four spines on each side; supero-apical spur the longest on either side; metatarsi long, pubescent, with a few small denticulations above.

Elytra dark brown, extending nearly to the apex of abdomen, thick, in the shape of a nearly flat plate, narrow and rounded at the apex, their margins provided with long bristles, their surface pubescent. Venation obsolete; dorsal field with three furcate veins; lateral field narrow and short, extending only a little beyond the middle of the elytron, without any distinct veins.

♀.—Wholly apterous; coloration a little darker than in the male, but presenting the same peculiarities; face mostly brown. Abdomen brown above, with a median line and two series of lateral spots yellowish. Ovipositor rather long, straight, with very acute apical valves, the superior ones strongly notched at the base; subgenital plate small, narrowing but rounded at apex.

Length of body, ♂ 11·5 mm., ♀ 12·5 mm.; pronotum 2·2 mm.; posterior femora, ♂ 10 mm., ♀ 12 mm.; posterior tibiae, ♂ 10·5 mm., ♀ 12·5 mm.; elytra, ♂, 6 mm.; ovipositor 13 mm.

This species is remarkable for its long and narrow elytra. It resembles certain species of *Phaeophilacris*, but the ♂ lacks the serrulation of the anterior femora, so that it fits better into the genus *Speluncacris*.

Podoscirtinae.

Euscyrtus maculipennis Chop.

Loc. Muger Valley, ca. 5500 ft., 28–29. xii, 1 ♀ (*Scott*).

This species was known from the Belgian Congo only (cf. Chopard, 1925, Ann. Soc. ent. Fr. xciv, p. 331).

TETTIGONIIDAE.

Phaneroptera nana Fieber.

Loc. Hawash River, west of Mt. Zuquala, ca. 6000 ft., 28. xi, 1 ♀ (*Omer-Cooper*); Muger valley, ca. 5500 ft., 28–29. xii, 3 ♂♂, 1 ♀ (*Scott*).

PANTOLEPTA HETEROMORPHA Karsch.

Loc. Wambar Mariam, Mt. Zuquala, ca. 7000 ft., 28. x, 1 ♂ (*Scott*). Described from Mombasa.

TYLOPSIS sp.

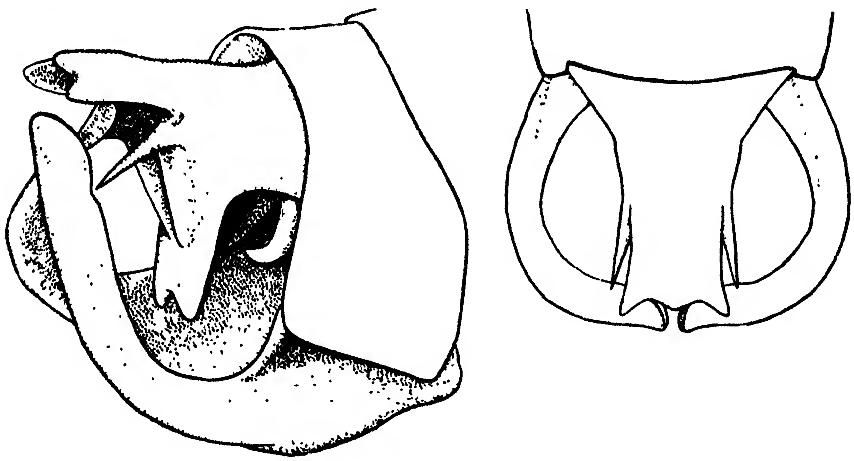
Loc. Hawash River, west of Mt. Zuquala, ca. 6000 ft., 28. xi, 2 ♀♀ (*Omer-Cooper*).

Impossible to determine specifically from the female sex only.

PEROPYRRHICIA SCOTTI, sp. n. (Text-fig. 2.)

♂.—Pronotum short and broad, somewhat saddle-shaped, rugose and punctured; lateral lobes elongate, their front angle slightly more than 90°, lower margin straight, hind angle broadly rounded, hind margin slightly excised.

TEXT-FIG. 2.



Peropyrrhicia scotti, sp. n.
Male external genitalia, seen obliquely from the side and from above.

Elytra coriaceous, longer than pronotum; their apical external angle acute, but broadly rounded.

Hind femur with 1–2 minute black spinules on each of the lower carinae near the apical part.

Last tergite elongated into a subconical appendage, the apex of which is trilobed, the middle lobe being rounded and the lateral ones conical, acute. Below the base of the appendage there is a pair of acute spines as long as the appendage and directed obliquely backwards. Supra-anal plate is fused with the appendage, hanging vertically underneath its base; it is elongate-trapezoidal in shape, with the apex triangularly emarginate. Cerci short, strongly curved, pointed. Subgenital plate very large; basal part transverse, with a very broad round emargination behind; the branches widely divergent

at first, then convergent under the appendage of the last tergite; they are slightly expanded near the apex and provided by a small tubercle on the inner side at the base of the apical third.

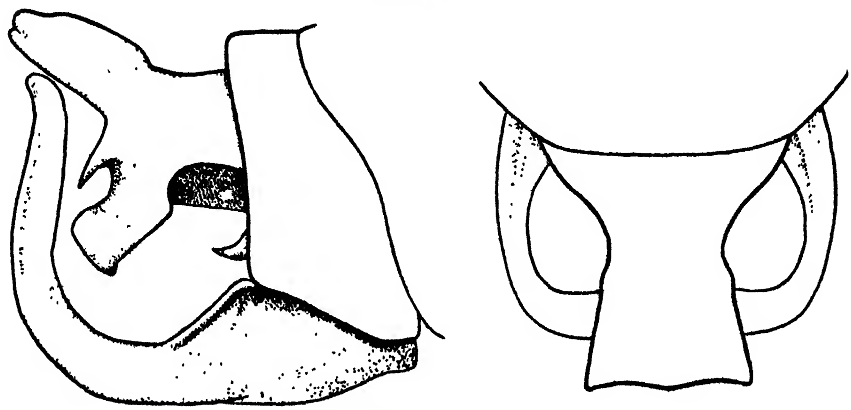
Pronotum, elytra above, and abdomen reddish brown; other parts mainly green. First and second antennal joints black below; the rest of the antennae brown, with pale rings at the base of joints. Tympanum of front tibia black.

Total length 17; pronotum 3·5; elytra 5; front femur 7·5; hind femur 3 mm.

Loc. Between Jem-Jem and Addis Ababa, 7000–8000 ft., 11–14. x, 1 ♂ (*Scott*).

Easily recognizable by the terminal abdominal structures.

TEXT-FIG. 3.



Peropyrrhicia cooperi, sp. n.
Male external genitalia, seen from the side and from above.

PEROPYRRHICIA COOPERI, sp. n. (Text-fig. 3.)

♂.—Pronotum moderately elongate, distinctly saddle-shaped, strongly rugose; lateral lobes as in *P. scotti*, but the surface very uneven.

Elytra longer than pronotum; their apical external angle slightly less than 90°, rounded.

Hind femur with 3 inner and 4–5 outer black spines along the lower carinae.

The appendage of the last tergite is widened towards the apex, which is rounded-truncate, with acute lateral angles; spines underneath the base of the appendages short. Supra-anal plate inflated and emarginate at the apex. Cerci short, strongly curved, pointed. Subgenital plate similar to that of *P. scotti*, but the appendages are not expanded apically and there is no pre-apical tubercle on the inner side.

General coloration yellowish green; black markings as in *P. scotti* (paratypes reddish brown).

Total length 17; pronotum 3·5; elytra 5; front femur 8; hind femur 15·5 mm.

Loc. Jem-Jem Forest, 8000–9000 ft., 22–24. ix, 2 ♂♂, type and paratype (*Scott*); Mt. Zuquala, ca. 9000 ft., 24–25. x, 1 ♂, paratype (*Omer-Cooper*).

PHLESIRTES BRACHIATUS Uvarov.

Loc. Jem-Jem Forest, ca. 8000 ft., 23–24. ix, " from grassy open spaces," 1 ♂, 1 ♀; the same, nearly 9000 ft., 24. ix, 1 ♀, and ca. 8000 ft., ix–x, " near house," 13 ♂♂, 5 ♀♀; the same, 4. x, " grassy meadow at forest edge," 1 ♂; Mt. Zuquala, ca. 9000 ft., 21–25, x, 1 ♀; Mt. Chillalo, Digalla, ca. 9500 ft., 26–27. xi, 2 ♂♂, 4 ♀♀ (*Scott*).

The species was described from a single male from some unknown locality in British East Africa, and the Abyssinian specimens do not differ from the type.

HOMOROCORYPHUS NITIDULUS (Scopoli).

Loc. Doukam, 6500–7000 ft., 20. x, 1 ♀ (*Scott*); Mt. Zuquala, ca. 9000 ft., 21–25. x, 1 ♀ (*Scott*); Mt. Zuquala, Wambar Mariam, ca. 7000 ft., 28. x, 1 larva ♀ (*Scott*); plains north-west of Lake Zwai, 5500–6000 ft., 31. x–4. xi, 2 ♂♂, 1 ♀ (*Scott*); Mt. Chillalo, ca. 8000 ft., 6–8. xi, 1 ♀ (*Scott*); between Lake Zwai and Lake Hora Abjata, 5000–5500 ft., 15–16. xi, 1 ♀ (*Omer-Cooper*); Muger valley, ca. 5500 ft., 28–29. xii, 1 ♂ (*Scott*).

CONOCEPHALUS CONOCEPHALUS (Thunberg).

Loc. Doukam, 6500–7000 ft., 18–19. x, 3 ♂♂, 1 ♀ (*Scott*); Hawash River, west of Mt. Zuquala, ca. 6000 ft., " from rushes on river bank," 29. x, 2 ♂♂, 1 ♀ (*Scott*); Lake Hora Abjata, 17. xi, 1 ♂, 1 ♀, and marsh near the same, ca. 5000 ft., 18. xi, 7 ♂♂, 6 ♀♀ (*Omer-Cooper*); Hawash River, west of Mt. Zuquala, ca. 6000 ft., 28. xi, 2 ♂♂, 4 ♀♀ (*Omer-Cooper*); Muger Valley, ca. 5500 ft., 28–29. xii, 3 ♂♂, 2 ♀♀ (*Scott*).

MEGALOTHECA sp.

Loc. Plains north-west of Lake Zwai, 5500–6000 ft., 31. x–1. xi, 1 ♀ (*Scott*).

Probably an undescribed species, but it would be unwise to base a description on a single female, with incomplete abdomen.

SPALACOMIMUS INERMIS, sp. n. (Text-fig. 4.)

♀.—Head, particularly the occiput, coarsely punctured. Vertex with a low, broad, triangular tubercle.

Pronotum very uneven, with tubercles and coarse punctures. Front margin shallowly tri-emarginate, without spines, which are replaced by small obtuse tubercles. Lateral margins of the disc with only low tubercles. Transverse depressions broad, distinct. Metazona rounded behind, with a pair of very small sublateral tubercles, and two low tubercles on the sides, the lower one being larger and obtusely conical.

Abdomen smooth, shiny, with small scattered punctures.

Front coxa unarmed; front femur not incrassate, unarmed below; front tibia with five spines externally and internally. Middle and hind femur

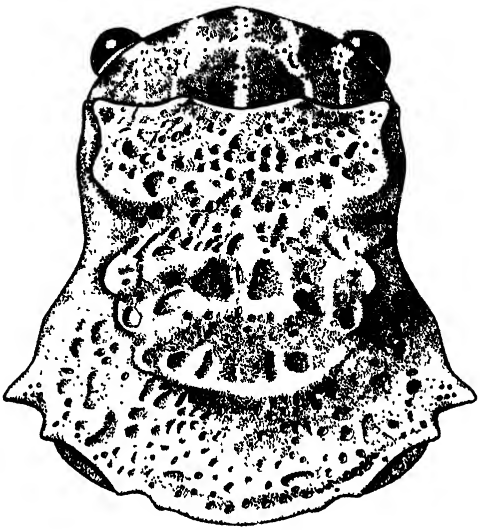
unarmed; hind tibia with five external and six internal spines, all near the apex, but not in a short dense row, as is the case in *S. talpa*.

General colour dark brown. Head pale buff, with black chequered pattern; occiput with five buff lines separated by interrupted black fasciae. Pronotum with irregular black spots and a pale median line on the disc; lateral lobes pale brown below, black above. Abdomen bronze-brown, with a buff median stripe. Legs spotted with black.

Total length 33; pronotum 11; hind femur 13 mm.

Loc. Mt. Zuquala, ca. 9000 ft., 5. x, 2 ♀♀, type and paratype; 24–25. x, 1 ♀, paratype (*Omer-Cooper*).

TEXT-FIG. 4.



Spalacomimus inermis, sp. n.

The new species differs from *S. talpa*, the only other known species of the genus, in the very short tubercle of the vertex, the unarmed femora, the greatly reduced armature of the pronotum, and particularly in the normal arrangement of the internal spines of the hind tibiae, as contrasted with the specialisation observed in *S. talpa*.

ACRIDIDAE.

ACRIDA REDUCTA I. Bolivar.

Loc. Near Addis Alam, ca. 8000 ft., 18–19. ix, 2 ♂♂ (*Omer-Cooper*); Akaki ravine, 6500–7000 ft., 17. x, 2 ♂♂, 2 ♀♀ (*Scott*); Mt. Zuquala, Wambar Mariam, ca. 7000 ft., 28. x, 1 ♂ (*Scott*); Mt. Chillalo, ca. 8000 ft., 11. xi, 1 ♂, 1 ♀ (*Scott*); south-east of Lake Zwai, ca. 5500 ft., 10–13. xi, 1 ♂ (*Omer-Cooper*); Hawash River, west of Mt. Zuquala, ca. 6000 ft., 28. xi, 1 ♀ (*Omer-Cooper*); between Hawash River and Addas, 6000–7000 ft., 28–30. xi, 1 ♀ (*Omer-Cooper*).

Described from Harar.

Acrida deminuta I. Bolivar.

Loc. Mt. Zuquala, Wambar Mariam, ca. 7000 ft., 28. x, 1 ♂ (*Scott*); plains north-west of Lake Zwai, 5500–6000 ft., 31. x–1. xi, 1 ♂ (*Scott*); *ibidem*, 3–4. xi, 3 ♂♂ (*Scott*); south-east of Lake Zwai, ca. 5500 ft., 10–13. xi, 1 ♀ (*Omer-Cooper*); Muger valley, ca. 5500 ft., 28–29. xii, 3 ♂♂, 2 ♀♀ (*Scott*).

Dr. Scott noted that this insect makes a clicking noise during flight.

Described from Karssa in Abyssinia.

Acridella sp.

Loc. Hawash railway-station, ca. 3500 ft., 2. ix, 1 ♂, 1 ♀ (*Omer-Cooper*).

The specimens have been preserved in alcohol and are therefore indeterminable.

Cannula sulcata Sjöstedt ?

Loc. Mulu, above Muger valley, ca. 8000 ft., 18–23. xii, 2 ♂♂ (*Scott*).

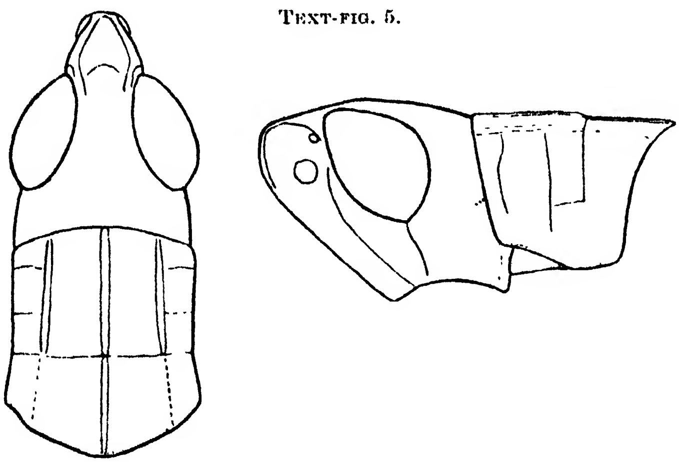
The description of this species is exceedingly brief, and it is impossible to be certain of the identification.

Paracomacris abyssinicus, sp. n. (Text-fig. 5.)

A brachypterous species allied to *P. elgonensis* Uvarov, 1930.

♂ (*type*).—Antennae considerably longer than head and pronotum together, stout, flattened, and slightly expanded near the base.

Text-fig. 5.



Paracomacris abyssinicus, sp. n.

Face strongly oblique. Frontal ridge in profile straight except near the fastigium, where it is convex; viewed from the front it is slightly narrowed in the middle portion; surface sulcate throughout. Lateral facial keels sharp, convex. Fastigium of vertex narrowly parabolic, strongly prominent in front, much longer than broad; surface scarcely concave, with a faint curved transverse sulcus; margins sharp, smooth.

Pronotum with the disc scarcely tectiform; metazona with weak irregular longitudinal rugosities. Lateral carinae parallel, low and obtuse in the pro-zona, obsolete in the metazona. Posterior margin broadly rounded. Lateral

lobes about as long as deep: surface distinctly convex and strongly rugulose; lower margin strongly ascendent in the anterior half.

Elytra extending to about the middle of the abdomen and not reaching the middle of hind femur; all the veins straight, distinct; costal margin strongly projecting near the base.

General coloration dark brown, with a paler stripe along the lower half of the head and pronotal lobes; hind femora blackened apically.

♀ (*paratype*).—Antennae not reaching hind margin of pronotum. Frontal ridge shallowly sulcate, punctured. Fastigium of vertex elongate-oval: surface slightly convex; margins obtuse, punctured.

Total length, ♂ 13, ♀ 20·5; pronotum, ♂ 3, ♀ 4·5; elytra, ♂ 5·5, ♀ 8; hind femur, ♂ 8, ♀ 12 mm.

Loc. Wouramboulchi, near Jem-Jem, ca. 9000 ft., 4–7. x, 2 ♂♂, type and paratype (*Omer-Cooper*); Mt. Chillalo, moorland, ca. 10,000 ft., " from short turf dotted with bush heath," 22. xi, 4 ♀♀, paratypes (*Scott*).

Representatives of this genus are amongst the most abundant and common grasshoppers of African grasslands, but practically all of them possess fully developed organs of flight. An exception is offered by *P. elgonensis*, recently described from the altitude 12,000 ft. in Mt. Elgon (see Ann. & Mag. Nat. Hist. (10) v, p. 249, 1930), and the present species, which are both brachypterous, as is very often the case with alpine Orthoptera.

PARACOMACRIS DECEPTOR Karsch ?

Loc. Addis Ababa, ix, 2 ♂♂ (*Omer-Cooper*); near Addis Alam, 8000 ft., 18–19. ix, 2 ♂♂ (*Scott*); between Addis Alam and Jem-Jem, 7000–8000 ft., 20. ix. 17 ♂♂, 4 ♀♀ (*Scott*); Jem-Jem Forest, 8000–9000 ft., 22–26. ix, from grassy open spaces, 12 ♂♂, 15 ♀♀ (*Scott*); Akaki ravine, 6500–7000 ft., 17. x, 1 ♂, 1 ♀ (*Scott*); Doukam, 6500–7000 ft., 18–20. x, 2 ♂♂, 1 ♀ (*Scott*); plains north of Lake Zwai, 5500–6000 ft., 3–4. xi, 3 ♂♂, 4 ♀♀ (*Scott*); Mt. Chillalo, 7000–8000 ft., 8–9. xi, 1 ♂ (*Omer-Cooper*); Muger valley, ca. 5500 ft., 28–29. xii, 5 ♂♂, 1 ♀ (*Scott*); the British Museum also possesses Abyssinian examples taken some years before the Expedition of 1926, as follows:—Lake Zwai, 19. v. 1914, 3 ♂♂, 1 ♀ (*Kovacs*).

There is a considerable degree of variation in the long series of specimens before me, but it would be very unwise to attempt describing new species, or subspecies, without revising the whole available material of the genus. This I am unable to do at present, and must of necessity leave my specific determination under some doubt.

PLATYPTERNA GRACILIS Krauss.

Loc. Hawash railway-station, ca. 3500 ft., 2. ix, 5 ♂♂, 3 ♀♀ (*Omer-Cooper*).

Known from the Sahara, Egypt, Sudan, and Arabia (see Salfi, Eos, vii, 1931, p. 331).

DURONIA TRICOLOR (Karny) ?

Loc. Doukam, 6500–7000 ft., 18–20. x, 3 ♂♂ (*Scott*); Hawash River, west

of Mt. Zuquala, ca. 6000 ft., 29. x, 1 ♀ (*Scott*); plains north-west of Lake Zwai, 5500–6000 ft., 31. x–4. xi, 2 ♂♂, 1 ♀ (*Scott*).

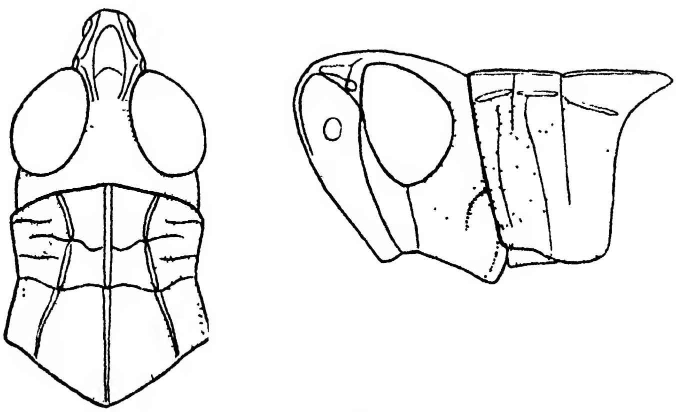
The description of this species, known from the Sudan, is very meagre and does not permit of a certain identification.

GYMNOBOTHRUS LINEA-ALBA I. Bolivar.

Loc. Wambar Mariam, Mt. Zuquala, ca. 7000 ft., 1 ♂, 2 ♀♀ (*Scott*).

The species was originally described from Angola, and appears to be widely distributed in South and East Africa. There are in the British Museum specimens from Lake Zwai, Abyssinia, collected 19. v. 1914 (*O. Kovacs*), and I am unable to find any appreciable characters differentiating the Abyssinian specimens and those from Angola and other African localities.

TEXT-FIG. 6



Gymnobothrus inflexus, sp. n

GYMNOBOTHRUS INFLEXUS, sp. n. (Text-fig. 6.)

Closely resembling *G. linea-alba*, but differing in the shape of the lateral pronotal keels.

♂.—Antennae longer than head and pronotum together, very stout, slightly flattened near the base.

Face strongly oblique, rugose. Frontal ridge slightly convex in profile: the surface practically flat, but heavily punctured, except the margins, which are smooth and obtuse. Fastigium of vertex projecting strongly forward, elongate-oval; surface feebly concave; lateral sloping margins punctured, with irregular, elongate, deep foveolae. Occiput rugulose.

Pronotum rugulose. Median keel well raised, cut by the typical sulcus in the middle. Lateral keels regularly bow-shaped, incurved in the prozona, divergent and slightly outcurved in the metazona, callous throughout, obsolescent only quite close to the hind margin. First transverse sulcus intersecting the lateral keels, the second one obliterated. Lateral lobes much deeper than long; lower margin strongly excised anteriorly.

Elytra extending a little beyond the hind knees.

General coloration pale chocolate-brown, with black and dark brown pattern. Anterior portion of cheeks, lower half of lateral pronotal lobes, and the adjoining part of the pleurae pale buff. Posterior portion of cheeks and upper portion of lateral pronotal lobes dark chocolate-brown, becoming velvety-black at the upper and the lower boundary of the marks. Eyes margined with velvety-black on the inner side. Disc of pronotum buff; metazona with velvety-black stripes adjoining ivory-yellow lateral keels on the inside, while in the prozona the keels are margined with velvety-black on the outside. Elytra with an ivory-white callous scapular stripe and a blackish, practically uninterrupted, stripe along the discoidal field; anal field buff, with some brown dots. Hind femur with the externo-median area darkened along the upper edge; upper area with small black spots about the middle; knees dark brown. Hind tibia dirty testaceous. Abdomen with broad interrupted blackish-brown lateral fasciae.

Total length 12; pronotum 2·5; elytra 10·5; hind femur 8 mm.

Loc. Mt. Chillalo, moorland, ca. 10,000 ft., 22. xi. 1926, " from short turf dotted with bush heath," 1 ♂ (*Scott*).

Zacompsa sp.

Loc. Wambar Mariam, Mt. Zuquala, ca. 7000 ft., 28. x, 1 ♀ (*Scott*).

Similar to *Z. brevipennis* Miller, but exact determination is impossible from a single female.

Aulacobothrus aethiopicus (I. Bolivar) ?

Loc. Mt. Chillalo, moorland, ca. 10,000 ft., " from short turf dotted with bush heath," 22. xi, 1 ♂, 1 ♀ (*Scott*): Mulu, above the Muger valley, ca. 8000 ft., 18–23. xii, 2 ♂♂, 1 ♀ (*Scott*).

The identification cannot be certain, because Bolivar's description is very meagre and contains no mention even of the shape of the pronotal keels, which in the specimens before me are obtusely inflexed in the middle of the prozona and diverge behind more than in front.

Pnorisa squalus Stål.

Eleutherotheca elegans Karny, Sitzungsber. Akad. Wiss. Wien, math.-nat. Kl. cxvi, Abt. i, p. 361, 1907 (*syn. nov.*).

Loc. Hawash railway-station, ca. 3500 ft., 2. ix, 1 ♀ (*Omer-Cooper*); plains north-west of Lake Zwai, 5500–6000 ft., 31. x–1. xi, 1 ♂ (*Scott*).

The above synonymy is based on the examination of the type of *E. elegans*, kindly communicated by the Vienna Museum, thanks to the assistance of Dr. R. Ebner *.

* The genus *Eleutherotheca* was described by Karny to include two species, *elegans* and *concolor*, the latter designated as the genotype. The type of *concolor* proved on examination to be congeneric with *Apnorisa fungosa* I. Bolivar. The genus *Apnorisa* included originally two species, but the genotype was not fixed. I select here *A. fungosa* as the type of *Apnorisa*, and the following generic synonymy is the result :—*Eleutherotheca* Karny, 1907 = *Apnorisa* I. Bolivar, 1909 (*syn. nov.*).

FAUREIA * COERULESCENS Miller.

Faureia milanjica (Karsch) var. *coerulescens* Miller, Trans. Ent. Soc. London, lxxvii, p. 71, 1929.

Loc. Mt. Chillalo, ca. 8000–9500 ft., 11–15. xi, 2 ♂♂, 2 ♀♀ (*Scott*); north of Mt. Chillalo, Boru stream, ca. 7500 ft., 29. xi, 2 ♂♂, 1 ♀ (*Scott*); Mulu, above Muger valley, ca. 8000 ft., 2 ♀♀ (*Scott*).

CALEPHORUS COMPRESSICORNIS (Latr.), subsp. ?

Loc. Muger valley, ca. 5500 ft., 28–29. xii (*Scott*).

A very long series of specimens, which appear to differ from the European ones by the longer antennae and more acute fastigium of the vertex. A detailed critical study of specimens from various countries would be necessary to establish the taxonomic value of these differences.

AIOLOPUS THALASSINUS (Fabricius).

Loc. Near Addis Alam, ca. 8000 ft., 18–19. ix, 1 ♀ (*Omer-Cooper*); between Addis Alam and Jem-Jem, 7000–8000 ft., 20. ix, 1 ♂, 3 ♀♀ (*Scott*); plains north of Lake Zwai, 5500–6000 ft., 3–4. xi, 6 ♂♂, 4 ♀♀ (*Scott*); marsh near Lake Hora Abjata, ca. 5000 ft., 18. xi, 4 ♂♂, 1 ♀ (*Scott*); Muger valley, ca. 5500 ft., 28–29. xii, many specimens (*Scott*); Hawash River, near Jilli, ca. 5500 ft., 7 ♂♂, 2 ♀♀ (*Scott*).

AIOLOPUS sp.

Loc. Muger valley, ca. 5500 ft., 28–29. xii, 1 ♂ (*Scott*).

A species similar to *A. longicornis* Sjöst., from East Africa, but the only specimen is not well preserved, and an exact determination is not possible.

PARACINEMA sp.

Loc. Near Addis Alam, ca. 8000 ft., 18–19. ix, 1 ♂ (*Omer-Cooper*); Wouramboulchi, near Jem-Jem, ca. 9000 ft., 4–7. x, 25 ♂♂, 14 ♀♀ (*Omer-Cooper*); Akaki ravine, 6500–7000 ft., 17. x, 4 ♂♂, 3 ♀♀ (*Scott*); Mulu, above the Muger valley, ca. 8000 ft., 18–23. xi, 1 ♂ (*Scott*); north of Mt. Chillalo, Boru stream, ca. 7500 ft., 29. xi, 1 ♀ (*Scott*).

At the Akaki River and the Boru stream individuals, disturbed by the sweeping-net, leapt from the grass on the bank into the water and swam well, according to the normal habit of these insects.

It has been customary to identify all African specimens of this genus as *P. tricolor* Thunberg, but the genus requires a thorough revision and in the meantime the use of any specific names has no value.

* The genus *Faureia* was described by me (Ann. & Mag. Nat. Hist. (9) viii, p. 389, 1921) with *F. rosea* Uv. as the genotype. To the same genus I refer, after examining a cotype, *Rhaphotittha milanjica* Karsch, and the species determined by Sjöstedt as *Chorthoicetes subparallelus* Rehn, and made by him the type of his genus *Ugandella* (Ark. Zool. xv. no. 6, p. 20, 1923). Paratypes of *Ch. subparallelus* Rehn have been examined by me and found to represent a species of *Gymnobothrus*, and to differ widely from *Ugandella subparallela* Sjöst. (*nec* Rehn !). The following generic synonymy must be established :—*Faureia* Uvarov, 1921 = *Ugandella* Sjöstedt, 1923 (*syn. nov.*).

OEDALEUS CEPHALOTES, sp. n. (Text-fig. 7.)

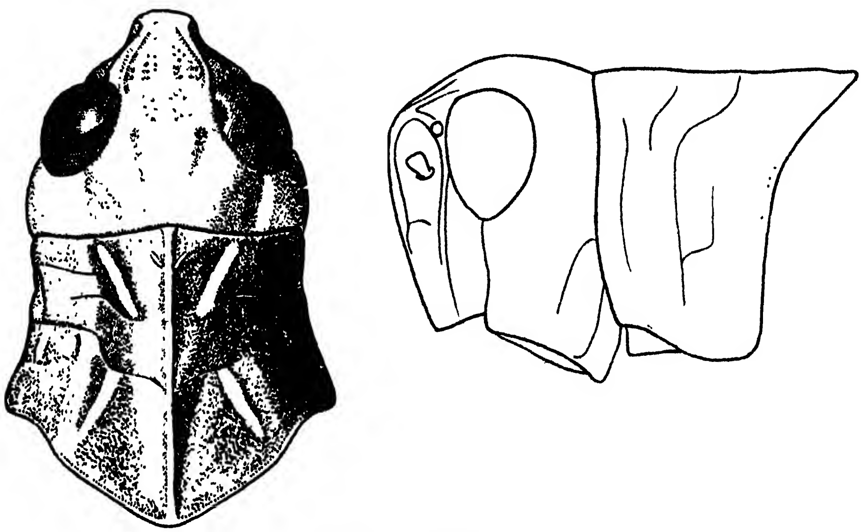
A small species, with relatively very large head, short pronotum with the median keel straight in profile, and incomplete wing-band.

♀ (*type*).—Antennae as long as head and pronotum together.

Head thicker than pronotum. Frontal ridge straight in profile, weakly concave at the ocellum. Fastigium of vertex strongly sloping, pyriform, distinctly carinate all round. Lateral facial keel, seen in profile, bow-shaped.

Pronotum short, weakly saddle-shaped; its surface moderately rugulose and punctured. Anterior margin very obtusely angulate; posterior angle obtuse. Metazona shorter than prozona. Median keel acute, seen in profile quite straight.

TEXT-FIG. 7.



Oedaleus cephalotes, sp. n.

Elytra extending just beyond hind knees.

General coloration as in other species of the genus. Decussate whitish lines of the pronotum narrow, bent under an obtuse angle. Elytra with the dark markings in the basal half more extensive than the pale ones. Wings faintly yellowish; a narrow fascia only in the posterior part; apex infumate. Hind femur with reduced typical dark pattern on the outside, reddish on the inner and lower side. Hind tibia pale red.

♂ (*paratype*).—Frontal ridge sulcate for a short distance below the ocellum.

Total length, ♂ 21, ♀ 29; pronotum, ♂ 4, ♀ 5·5; elytra, ♂ 17, ♀ 22; hind femur, ♂ 13, ♀ 17 mm.

Loc. Wambar Mariam, Mt. Zuquala, ca. 7000 ft., 28. x, 1 ♀; plains north-west of Lake Zwai, 5500–6000 ft., 31. x–1. xi, 1 ♀; Muger valley, ca. 5500 ft., 28–29. xii, 1 ♀, type (*Scott*); Abyssinia, 1 ♂ (British Museum).

HUMBE TENUICORNIS (Schaum).

Loc. Between Lake Zwai and Makki River, 5500-6000 ft., 23-24. xi, 1 ♂ (*Omer-Cooper*).

GASTRIMARGUS AFRICANUS Saussure.

Loc. Mt. Zuquala, Wambar Mariam, ca. 7000 ft., 28. x, 1 ♂, 1 ♀ (*Scott*); small stream between Hawash and Lake Zwai, ca. 6000 ft., 1 ♀ (*Omer-Cooper*).

GASTRIMARGUS BREVIPES Sjöstedt, subsp. ?

Loc. Hawash River, west of Mt. Zuquala, ca. 6000 ft., 29. x, 1 ♀ (*Scott*). Exact determination is impossible from a single female.

GASTRIMARGUS ROTHSCHILDI I. Bolivar subsp. MONTANUS, nov.

Agrees with the description of the typical form in all essential characters, but the measurements are considerably smaller, as follows (measurements of the typical form in brackets) :—

Length of body, ♂ 17, ♀ 28 (39); pronotum, ♂ 6, ♀ 10 (14); elytra, ♂ 15, ♀ 17 (24): hind femur, ♂ 12, ♀ 17 (22) mm.

Loc. Mt. Chillalo, moorland, ca. 10,000 ft., " short turf dotted with bush-heath," 22. xi, 6 ♂♂ (including the type), 1 ♀ (*Scott*); do., 17-19. xi, 1 ♂ (*Scott*); Mt. Chillalo, ca. 9500 ft., " open short turf," 15. xi, 4 ♂♂, 2 ♀♀ (*Scott*); Mt. Chillalo, Digalla, ca. 9500 ft., 26. xi, 1 ♂ (*Scott*); Mt. Zuquala, ca. 9000 ft., 24-25. x, 7 ♂♂ (*Omer-Cooper*); Jem-Jem Forest, 8000-9000 ft., 23-26. ix, 1 ♂ (*Scott*): Wouramboulchi, near Jem-Jem, ca. 9000 ft., 4-7. x, 1 ♂, 1 ♀ (*Omer-Cooper*).

LOCUSTA MIGRATORIA MIGRATORIOIDES (Reiche et Fairmaire).

Loc. Doukam, 6500-7000 ft., 18. x, 1 ♀ (*Scott*).

A perfectly typical specimen of the ph. *gregaria* of the Tropical Migratory Locust. The record is of some interest, since swarms of this species did not appear in Abyssinia until two years later, in 1928. It would seem that the swarming phase may occasionally be produced locally, though there is no reason to think that swarms were present in Abyssinia in 1926.

[A few days later, 27. x. 1926, in the coarse grass and other herbage on the flat floor of the crater of Mt. Zuquala, I knocked up several large locusts which I failed to capture. I had so close a view of them as they flew past, that I am nearly sure they were individuals of two phases of the Migratory Locust, one being almost certainly the *solitaria*-phase, recognisable by the amount of green in its coloration. These observations are mentioned, because the flat marshy ground surrounding the lake in the crater of Zuquala, at about 9000 ft., is a spot where this species might be expected to occur.—HUGH SCOTT.]

SCINTHARISTA NOTABILIS BRUNNERI Saussure.

Loc. Hawash railway-station, ca. 3500 ft., 2. ix, 1 ♀ (*Omer-Cooper*).

HETEROPTERNIS MINUTA, sp. n. (Text-fig. 8.)

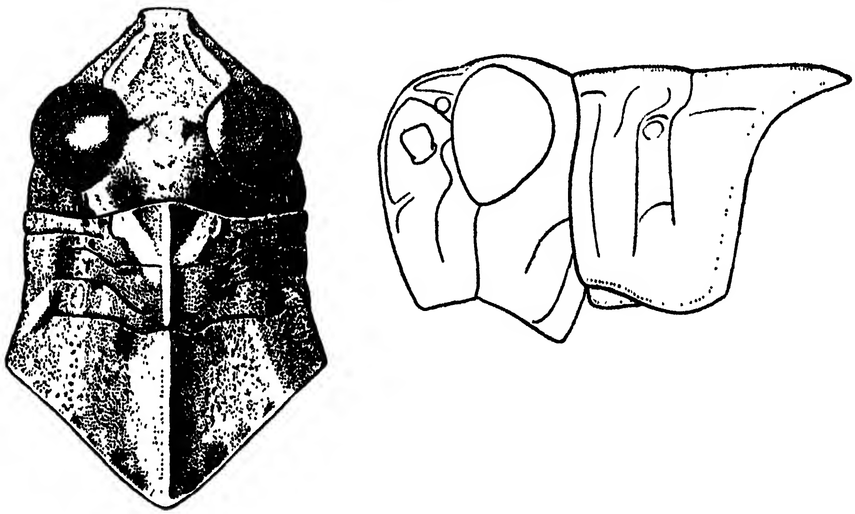
Smaller than any known species.

♂ (*type*).—Antennae longer than head and pronotum together.

Frontal ridge feebly convex in profile; its surface with a foveola near the fastigium and a depression at the ocellus. Fastigium of vertex feebly sloping, a little longer than broad; its apex truncate; lateral keels slightly incurved. Foveolae of vertex very long, narrow, strongly margined.

Pronotum relatively long; its surface rugulose. Anterior margin feebly rounded-prominent; posterior angle almost acute. Median carina very acute, straight in profile, intersected by the typical sulcus in the middle. Lateral carinae represented at the anterior margin by short curved carinulae.

TEXT-FIG. 8.



Heteropternis minuta, sp. n.

Elytra reaching the apex of the hind knees. The discoidal field occupies more than the basal two-thirds.

General coloration dark brown, with the black markings forming the usual pattern. Pale decussate pattern on the pronotum indistinct. Elytra dark brown, black at the base, becoming lighter near the apex. Wings light reddish orange basally, gradually turning smoky elsewhere. Hind femur on the inner and lower side, and hind tibia, reddish orange.

♀ (*paratype*).—Pronotum with the posterior margin rectangular, the angle rounded.

Total length, ♂ 13, ♀ 20; pronotum, ♂ 3·5, ♀ 4·5; elytra, ♂ 10, ♀ 13; hind femur, ♂ 9, ♀ 12 mm.

Loc. Mt. Chillalo, moorland, ca. 10,000 ft., " from short turf dotted with bush-heath," 17–22. xi, 3 ♂♂ (including the type), 2 ♀♀ (*Scott*); Jem-Jem Forest, over 8000 ft., 10. x, 1 ♀ (*Scott*); Wooroomon, 1. iv. 1904, 1 ♀ (*C. Singer*).

A remarkably small species with peculiarly coloured hind wings. The specimens from Jem-Jem and Wooroomon are slightly smaller than those from the greater altitude, but do not differ from them otherwise.

Sphingonotus rubescens (Walker).

Loc. Muger valley, ca. 5500 ft., 28–29. xii, 1 ♂ (*Scott*).

Morphacris fasciata (Thunberg).

Loc. Mt. Zuquala, Wambar Mariam, ca. 7000 ft., 28. x, 1 ♀ larva (*Scott*); plains north of Lake Zwai, 5500–6000 ft., 3–4. xi, 6 ♂♂, 3 ♀♀ (*Scott*); Muger valley, ca. 5500 ft., "from long dry grass," 28–29. xii, 16 ♂♂, 12 ♀♀ (*Scott*).

Conipoda gracilis Miller ?

Loc. Muger valley, ca. 5500 ft., 28–29. xii, 4 ♂♂, 7 ♀♀ (*Scott*).

Abyssinian specimens are all darker coloured than the types, and the fastigium of their vertex projects a little more forward. It is impossible to assess the value of these differences in the present state of our knowledge of this difficult genus.

Acrotylus patruelis (Herrich-Schaeffer).

Loc. Debra Libanos, ca. 8000 ft., 2. i. 1927, 1 ♂; Akaki ravine, 6500–7000 ft., 17. x, 1 ♂; Wambar Mariam, Mt. Zuquala, ca. 7000 ft., 28. x, 3 ♀♀ (*Scott*).

Trilophidia sp.

Numerous specimens from various localities, which it would be superfluous to quote, since the African species of this genus are in absolute confusion and all existing records must be regarded as doubtful.

Chrotogonus spp.

There are apparently two species of this genus in the collection, but their identification is impossible, since the genus has never been properly revised.

Pyrgomorpha cognata Krauss.

Loc. Hawash railway-station, ca. 3500 ft., 2. ix, 1 ♂ (*Omer-Cooper*).

Parasphena montana, sp. n. (Text-fig. 9, M.)

♂ (*type*).—Antennae as long as head and pronotum together, thick; apical joint as long as the three joints preceding it.

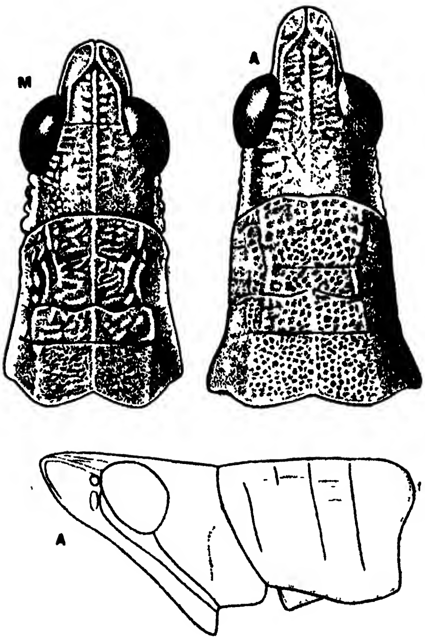
Frontal ridge narrowly sulcate throughout. Fastigium of vertex parabolic, about as long as its base is wide; sides straight, feebly divergent backwards. Median carinula distinct on the vertex, gradually obsolescent towards the pronotum. Upper surface of head wrinkled. Cheeks with a series of large callous tubercles.

Pronotum wrinkled all over, more coarsely in the prozona, while in the metazona the wrinkles are denser and finer. First transverse sulcus obsolete on the disc; second placed in the middle of the pronotum; third (typical) beyond the second third of the length. Median carina irregular, but distinctly raised throughout. Lateral carinae still more irregular, but perceptible;

they are convergent backwards and somewhat incurved in front of the second sulcus, widely distant and thick between the sulci, fine and straight in the metazona. Posterior margin obtusely excised in the middle, with the sides of the excision rounded. Lateral lobe much longer than high, coarsely wrinkled; lower margin very slightly sinuate; hind margin shallowly excised. The visible part of the mesonotum is shorter than the metazona of the pronotum, with low wrinkles and low median carinula. Metanotum longer than pronotal metazona, obtusely wrinkled, with a low median carinula.

Prosternum with a distinct low conical tubercle. Metasternal lobes about as long as wide; their interspace slightly narrowed behind, where it is about as wide as one of the lobes.

TEXT-FIG. 9.



M, *Parasphena montana*, sp. n.; A, *Parasphena abyssinica*, sp. n.

Elytra very narrow, lanceolate, reaching the end of the metanotum.

Last tergite broadly emarginate. Supra-anal plate acutely triangular; its surface convex. Cercus conical, slightly incurved, a little shorter than the supra-anal plate. Subgenital plate obtuse.

General coloration olive-green. The raised wrinkles on the sides of the body, the tubercles on the cheeks, the lower margins of the lateral pronotal lobes, and the pleurae bright greenish yellow. Antennae black. Head and pronotum above reddish brown; median pronotal carina orange. Abdomen with a fairly broad dirty orange median stripe. Hind tibia olivaceous; tarsus reddish.

Total length, ♂ 15, ♀ 23; pronotum, ♂ 4, ♀ 5; elytra, ♂♀, 1·5; hind femur, ♂ 8·5, ♀ 10 mm.

Loc. Mt. Chillalo, moorland, ca. 10,000 ft., "from short turf dotted with bush-heath," 22. xi, 10 ♂♂, 3 ♀♀ (*Scott*).

PARASPHENA ABYSSINICA, sp. n. (Text-fig. 9, A.)

♂ (*type*).—Antennae thick, a little longer than head and pronotum together; apical joint a little shorter than the three joints preceding it.

Frontal ridge narrowly sulcate throughout, slightly expanded at the ocellus. Fastigium of vertex scarcely longer than at the base wide; apex elliptical; sides distinctly divergent backwards, a little incurved. Median carinula distinct. Upper surface of head not densely wrinkled. Cheeks with the tubercles low, flattened.

Pronotum not densely wrinkled all over; wrinkles of metazona denser and finer. First transverse sulcus perceptible, placed a little in front of the middle; second sulcus distinct, in the middle; third beyond the third quarter of the length. Median carina very irregular, interrupted. Lateral carinae quite irregular, scarcely perceptible, broadly inflexed. Posterior margin obtusely excised in the middle, with the sides of the excision rounded. Lateral lobe much longer than high, coarsely wrinkled; lower margin distinctly sinuate; hind margin shallowly excised. The visible part of the mesonotum is slightly wrinkled near the hind margin; median carina low. Metanotum half as long again as metazona of pronotum, shallowly but coarsely punctured, with a very low median carinula.

Prosternum with a small conical tubercle. Metasternal lobes longer than wide; their interspace narrower than one of the lobes.

Elytra moderately narrow, not reaching the end of the metanotum.

Last tergite with a parabolic excision. Supra-anal plate narrowly triangular, with the immediate apex rounded. Cercus concial, a little shorter than supra-anal plate. Subgenital plate obtuse.

General coloration pale greenish yellow, reddish above. Antennae reddish brown, with narrow pale rings at the apices of basal joints. Lower part of cheeks and of lateral pronotal lobes light yellow. Elytra reddish. Hind tibia dirty reddish stramineous; tarsus reddish. Abdomen with a pale orange median line.

Total length, ♂ 22, ♀ 30; pronotum, ♂ 4, ♀ 5; elytra, ♂ 2·5, ♀ 3; hind femur, ♂ 11, ♀ 13 mm.

Loc. West of Mt. Zuquala, at the Hawash River, ca. 6000 ft., 29. x, 1 ♂, 1 ♀ taken *in copula* (*Scott*).

PHYMATEUS PULCHERRIMUS I. Bolivar.

Loc. Mulu, above Muger valley, ca. 8000 ft., 18–23. xii, 1 ♂ (*Scott*).

LEPTACRIS VIOLACEA (Karny).

Loc. Muger valley, ca. 5500 ft., 28–29. xii, 1 ♂ (*Scott*).

TRISTRIA sp.

Loc. Hawash River, west of Mt. Zuquala, ca. 6000 ft., 28. xi, 3 ♀♀ (*Omer-Cooper*).

It would be unwise to identify the species from the female sex alone.

OXYA HYLA (Fabricius).

Loc. Muger valley, ca. 5500 ft., 28–29. xii, 6 ♂♂, 4 ♀♀ (*Scott*).

CATANTOPS MELANOSTICTUS Schaum.

Loc. Plains north of Lake Zwai, 5500–6000 ft., 3–4. xi, 3 ♂♂, 4 ♀♀ (*Scott*).

CATANTOPS sp.

Loc. Akaki ravine, 6500–7000 ft., 17. x, 3 ♀♀; Doukam, 6500–7000 ft., 18–19. x, 1 ♀ (*Scott*).

Similar in the femoral pattern to *C. somalicus* Sjöst. (Ark. Zool. 22 A, no. 15, p. 40, 1931), but specific identification impossible without a male.

NERITIUS (?) ABYSSINICUS, sp. n. (Text-fig. 10.)

♂.—Antennae as long as head and pronotum together.

Face in profile moderately oblique, feebly convex. Frontal ridge narrow at the fastigium, gradually and strongly widened towards the clypeus; surface feebly convex, punctured. Fastigium of vertex narrowly parabolic, longer than wide; surface slightly concave; margins raised, smooth; sides punctured. Vertex with a short carinula between the eyes.

Pronotum compressed sideways, but not constricted. Disc practically flat, rugulose in the metazona. Front and hind margins truncate. Median carina linear; lateral carinae weak but broad, shiny, punctured, obsolescent in the metazona. Transverse sulci well developed; third sulcus a little behind the middle. Lateral lobe shiny, with scattered punctures which are more dense in the metazona; lower margin obtusely angulate.

Prosternal tubercle cylindrical, slightly inclined backwards, with the apex rounded. Mesosternal lobes broader than long; their interspace about as wide as half of a lobe. Metasternal lobes contiguous behind the pits.

Elytra reaching a little beyond the end of the second tergite, narrowly elliptical, with the apex acute. Pre-radial field broad; all the longitudinal veins thick and straight.

Hind femur relatively short and thick. Hind tibia with eight outer and nine inner spines.

Last tergite with a semicircular excision in the middle and a small lobe on each side of the excision. Supra-anal plate longer than wide, elliptical, with the apex broadly triangular. Cercus compressed laterally; seen in profile broad at the base, but strongly narrowed towards the apex, which is somewhat decurved and sub-acute. Subgenital plate obtusely conical.

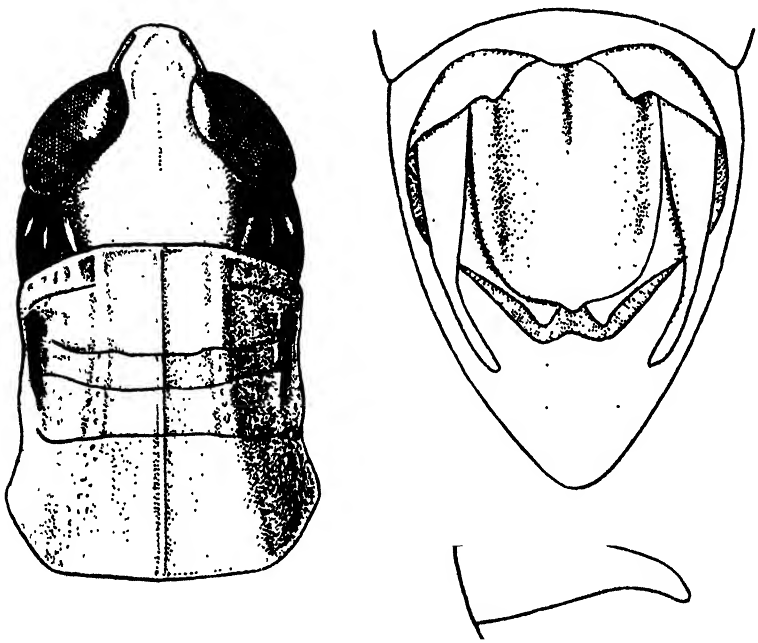
General coloration olivaceous. Face reddish brown; cheeks yellow. Sutures of clypeus, lateral margins of frontal ridge near antennae, subocular sulcus, and upper part of cheeks black. Pronotum above uniformly olivaceous,

turning reddish at the hind margin; lateral lobe with a large black spot, yellow under the spot and olivaceous above it.

Pleurae yellow, with black sutures. Elytra reddish brown. Abdomen yellowish, with indefinite dirty greenish lateral spots. Supra-anal plate yellowish along the middle, dirty brown laterally. Hind femur pale olivaceous above and on the outer surface, which becomes suffused with red near the base of the lower half; both lower sulci red in more than the basal half, that colour spreading on to the adjoining part of the inner side; the knee olivaceous above, black laterally, but the lobes ivory-white. Hind tibia in the basal half slate-blue with two indefinite yellowish fasciae below; apical half red; spines ivory-white with black tips. Hind tarsus red.

Total length 20; pronotum 4·5; elytra 5·5; hind femur 13 mm.

TEXT-FIG. 10.



Neritius (?) *abyssinicus*, sp. n.

Head and thorax; apex of abdomen from above; cercus from the side.

Loc. Jem-Jem Forest, 8000–9000 ft., 25–26. ix, 1 ♂ (*Scott*).

The generic determination of this insect is somewhat uncertain, since I. Bolivar described the genus from the female sex alone, and the best generic characters in this group are provided by the external genitalia of the male. It is true that, in the key to genera of the group compiled by the same author, the genus *Neritius* is separated from others by the shape of the subgenital plate of the unknown male, but this must be due to an error. Apart from this, the

genus is separated by its author mainly on the colour characters, although the types have been apparently preserved in fluid. On the other hand, the insect before me does not differ from the described female of *Neritius rothschildi* in any important morphological characters and I do not feel justified in erecting another poorly defined genus to include it, though this may become necessary when the male of *Neritius* is known.

I do not think that my new species is identical with *N. rothschildi*, in which the hind femur has no red colour and the hind tibia bears nine external and ten internal spines. These characters can scarcely be sexual.

CATALOIPUS PULCHER ABYSSINICUS, subsp. n.

Agrees in all essential characters with the typical form (known from Tanganyika Territory), but differs in its considerably smaller size and more strongly contrasted coloration.

Total length, ♂ 23, ♀ 43: pronotum, ♂ 5, ♀ 9; elytra, ♂ 17, ♀ 29; hind femur, ♂ 18, ♀ 29; hind tibia, ♂ 16, ♀ 26 mm.

Loc. Jem-Jem Forest, ca. 8000 ft., " near house," ix–x, 1 ♂ (*type*), 2 ♀♀; the same, over 8000 ft., " grassy glades at edge of forest," 22. ix, 2 ♂♂, 5 ♀♀; the same, 8000–9000 ft., 23–26. ix, 2 ♂♂, 2 ♀♀, and 8–9. x, 1 ♀; Akaki ravine, 6500–7000 ft., 17. x, 1 ♂, 1 ♀: plains north of Lake Zwai, 5500–6000 ft., 3–4. xi, 2 ♂♂ (*Scott*).

Cataloipus pulcher Sjöstedt is known to me through specimens from Manda, Tanganyika Territory, which agree very well with the original description, but the Abyssinian series differs very distinctly from them, while not exhibiting any individual variation.

C. pulcher abyssinicus is the smallest member of its genus hitherto described.

TYLOTROPIDIUS SPECIOSUS (Walker).

Loc. Hawash River, west of Mt. Zuquala, ca. 6000 ft., 28. xi, 1 ♂ (*Omer-Cooper*).

The specimen is somewhat smaller than those from the lowlands of Africa, and has relatively shorter hind femora.

TYLOTROPIDIUS sp.

Loc. Muger valley, ca. 5500 ft., 28–29. xii, 2 ♀♀ (*Scott*).

A species similar to *T. gracilipes* Brancs., but smaller and with shorter femora. A longer series of specimens of both sexes would be necessary for specific determination.

INDEX

[Synonyms are printed in *italics*. A star * denotes the first publication of a name; a dagger † denotes a fossil. The absence of an authority is due to omission by the respective authors.]

Acacesia lanceolata *Badcock* *, 3, 20.
Achnanthes (Microneis) Biasolettiana *Kutz.*, 259.
— (Achnanthidium) lanceolata *Bréb.*, 259; mentd., 254.
Achromadora tenax (*de Man*), 56, 75.
Acrida deminuta *I. Bolır.*, 601.
— reducta *I. Bolır.*, 600.
Acridella sp., 601.
Acrotylus patruelis (*Herrich-Schaeffer*), 609.
Actaea, mentd., 550.
ruppellii, mentd., 547, 549.
Actinolaimus tripapillatus (*Daday*), 56, 57, 87; mentd., 66, 79, 80, 86.
Adaptation to aerial respiration in Alma emini *Mich.*, an Oligochaet from East African swamps (Beadle), 347–350.
Aetheria elliptica, mentd., 187.
Agama rueppelli *Vaill.*, 223.
— — subsp. occidentalis *Parker* *, 225; mentd., 214.
— — subsp. rueppelli *Vaill.*, 224.
— — subsp. septentrionalis *Parker* *, 225.
— *vaillanti* Blgr., 224.
— *vaillanti* Lonnb., 225.
— *vaillanti* Loveridge, 225.
Agraptocorixa dakarica *Jacz.*, 346.
Aiolopus longicornis *Sjöst.*, mentd., 605.
— thalassinus (*Fabr.*), 591, 605.
Alestes nurse (*Rüpp.*), 123.
Algae from the East African Lakes (Rich), 249–275.
Alma emini *Mich.*, mentd., 145, 147; adaptation to aerial respiration (Beadle), 347–350.
Alouatta, mentd., 445.
Alpheus avarus, mentd., 547.
— edwardsi, mentd., 547.
macrochirus, mentd., 547.
— malleodigitus, mentd., 547–549.
Alysia manducator *Panz.*, mentd., 393.
Ammodytes lanceolatus, mentd., 368.
Ammosphaeroidina *Cushm.* †, 557.
Ampelisca, feeding habits, mentd., 363.
Amphibians from the East African Lakes (Parker), 213–229.
Amphiops *Er.*, 304.
Amphistegina lessonii *d'Orb.*†, 568.
Anabaena spp., 268; mentd., 254.
— *flos-aquae* (Lyng.) Bréb. var. *circularis* G. S. West, 268, 269.
— spiroides, mentd., 204.
Anabaenopsis, mentd., 189, 190, 204, 251.
— Arnoldii *Aptekarj* f. 'african' *Taylor*, 269; mentd., 253, 268.
— circularis (*G. S. West*) *Wolosz. & Mill.*, 268; mentd., 254.
— — var. javanica *Wolosz.*, mentd., 268.
— Cunningtonii, mentd., 269.
— tanganyikae (*G. S. West*) *Wolosz. & Mill.*, 269; mentd., 252–254.
Anabas, labyrinthine organ of, mentd., 50.
Anahita fauna *Simon*, mentd., 31.
Anapus, mentd., 244.
Anaspides, mentd., 385.
Androctonus (*Liurus*) *quinquestriatus* Hempr. & Ehrbg., 91.
Anisops (Anisops) amaryllis *Hutch.*, 345.
— (Micranisops) apicalis (*Stål*), 345.
— (Anisops) balcis *Hutch.*, 345.

Anisops (Anisops) eros *Hutch.*, 345.
— fieberi *Kirk.*, mentd., 343.
— (Anisops) pellucens *Gerst.*, 345.
— (—) sardea *H. S.*, 343; mentd., 344.
— (—) worthingtoni *Jacz.**, 343.
Ankistrodesmus falcatus (*Corda*) *Ralfs*, 256; mentd., 252, 255.
Anomalina glabrata *Cushm.*†, 570.
— rotula *d'Orb.*†, 570.
Anuraea, mentd., 246.
— aculeata *Ehrbg.* var. stipitata *Ehrbg.*, 238.
— — var. valga *Ehrbg.*, 238.
Anuraeopsis fissa (*Gosse*), 238, 466.
— *hypelasma* Gosse, 238.
— navicula *Rouss.* var. coelata *de Beauchamp* *, 238.
Aphanocapsa, mentd., 180, 195, 206, 210, 251.
— delicatissima *W. & G. S. West*, 265; mentd., 252.
— elachista *W. & G. S. West*, 265; mentd., 252.
— — var. planctonica *G. M. Smith*, 265; mentd., 255.
— Grevillei (*Hass.*) *Rabenh.*, 265; mentd., 252–255.
— pulchra (*Kütz.*) *Rabenh.*, mentd., 265.
Aphanolaimus aquaticus (*Daday*), mentd., 59–61.
— duodecim-papillatus *Kreis* *, 55, 56, 59.
— multipapillatus *Daday*, mentd., 60.
Aphanothece sp., 266; mentd., 252.
— nidulans *P. Richter*, mentd., 266.
Apistobuthus pterygocercus *Finnegan**, 92.
Apnorisa fungosa *I. Boliv.*, mentd., 604.
Aquatic Coleopterous Larvae from the East African Lakes (Imms), 301–307.
Aquatic Heteroptera from the East African Lakes (Jaczewski), 343–346.
Arabia, Scorpions from, collected by Mr. Bertram Thomas (Finnegan), 91–98.
Arachnida from the Paraguayan Chaco (Badcock), 1–48.
Araneus arenatus *Walck.*, mentd., 26.
— audax *Blackw.*, mentd., 24.
— carteri *Badcock* *, 3, 25.
— cylicophorus *Badcock* *, 3, 26.
— deliciosus (*Keys.*), 3, 23.
— gregalis (*Cambr.*), 3, 23.
— (Paramixia) guatemalensis *Cambr.*, mentd., 24.
Araneus inexplicabilis *Badcock* *, 3, 23.
— mexicanus *Lucas*, mentd., 26.
— nordenskiöldi *Tullgr.*, 3, 22.
— pentacanthus (*Walck.*), 3, 27.
— rugosus *Badcock* *, 3, 24.
— tabula *Simon*, mentd., 25.
— versicolor (*Keys.*), 3, 23.
Aratus pisonii (*Milne-Edwards*), mentd., 532–536.
Argiope argentata *Fabr.*, mentd., 19.
— argyrea *Badcock* *, 3, 19.
— simplex *Badcock* *, 3, 17.
— trifasciata (*Forsk.*), mentd., 17.
Argoracrites Sög., 395.
Argyrodes falcatus *Badcock**, 3, 9.
Arrhenurus, mentd., 284.
Arthrodesmus incus, mentd., 469.
Arthroleptis rouxi Angel, 217.
Arthrospira, mentd., 177, 183, 189, 190, 191, 192, 201, 202, 204, 205, 210.
— platensis (*Nordst.*) *Gomont*, 269; mentd., 191, 250–253.
— — f. minor *Rich.*, 271; mentd., 252.
Articulina †, 557.
Ascomorpha, mentd., 244.
— saltans *Bartsch*, 466; mentd., 469.
Asplanchna amphora *Huds.*, 232.
— brightwelli *Gosse*, 232, 466; mentd., 470, 471.
— priodonta *Gosse*, 466; mentd., 470, 471.
— *sieboldi* Leyd., 232.
Astatoreochromis alluaudi *Pellgr.*, 312, 313, 321; mentd., 310, 311.
Asterionella, mentd., 250, 465, 470.
— gracilis, 466.
— gracillima (*Hantzsch*) *Heiberg*, mentd., 251.
— — f. nov. *Rich*, 259; mentd., 254.
Atlasacris, mentd., 592.
Aubertin, D., Revision of the genus Lucilia *R.-D.* (Diptera, Calliphoridae), 389–436.
Aulacobothrus aethiopicus (*I. Boliv.*), 604.
Australopithecus †, mentd., 460, 462.
Azolla, mentd., 179.

Badcock, H. D., Arachnida from the Paraguayan Chaco, 1–48.
Baggina †, 559.
Barbus altianalis *Blgr.*, 124.

Barbus altianalis subsp. altianalis *Blgr.*, 125, 127.
— — subsp. eduardianus *Blgr.*, 125, 127.
— — subsp. radcliffii *Blgr.*, 125, 127.
— *bayoni* Blgr., 125.
— bynni (*Forsk.*) subsp. rudolfianus *Worthington* *, 123.
— degeni, mentd., 127.
— *eduardianus* Blgr., 125.
— *fergussoni* Blgr., 125.
— gregorii *Blgr.*, 124.
— leptosoma, mentd., 127.
— *lobogenys* Blgr., 125.
— meneliki *Pellgr.*, mentd., 124.
— nedgia, mentd., 127.
— *radcliffii* Blgr., 125.
— ruspolii *Blgr.*, mentd., 124.
Bargena, mentd., 286–288.
— mirifica *Koen.*, 284.
Bathynella, mentd., 385.
Bathyporeia, mentd., 386.
Beadle, L. C., Observations on the bionomics of some East African Swamps (Cambridge Expedition), 135–155; The waters of some East African Lakes in relation to their fauna and flora (Cambridge Expedition), 157–211; Adaptation to aerial respiration in Alma emini *Mich.*, an Oligochaet from East African swamps (Cambridge Expedition), 347–350.
Beauchamp, P. de, Rotifères et Gastrotriches from the East African Lakes (Cambridge Expedition), 231–248.
Bellia Spence Bate, 363.
Betaeus malleodigitus, mentd., 547, 548.
Bigenerina *d'Orb.*†, 557.
Biloculina spp.†, 557.
Bionomics of some East African Swamps (Beadle), 135–155.
Bitis arietans, mentd., 222.
— atropos (*Linn.*), mentd., 222.
— caudalis (*Smith*), mentd., 222, 223.
— cornuta, mentd., 223.
— gabonicus, mentd., 222.
— inornata, mentd., 223.
— worthingtoni *Parker* *, 221.
Blechroscelis azurea *Badcock* *, 3, 8.
— cyaneotaeniata *Keys.*, mentd., 8.
Bolivina *d'Orb.*†, 555.
Boschma, H., The Rhizocephala in the collection of the British Museum, 473–552.
Botryococcus, mentd., 188–190.
— Braunii *Kütz.*, 258; mentd., 253.
— protuberans *W. & G. S. West*, 258; mentd., 252.
Brachionus angularis *Gosse*, 236, 466; mentd., 470, 471.
— — var. caudata *Barrois & Daday*, 236.
— bakeri *Ehrbg.*, 238.
— — var. cluniorbicularis *Skorikov*, 238.
— budapestinensis *Daday*, 236.
— *calyciflorus* Pall., 236, 466, 470, 471.
— *capsuliflorus* Pall., 238, 466, 470, 471.
— falcatus *Zach.*, 238.
— leydigii *Cohn*, 466; mentd., 469–471.
— militaris *Ehrbg.*, 238.
— *mollis* Hempel, 233.
— *mülleri* Ehrbg., 238.
— pala *Ehrbg.*, 236; mentd., 177, 233–237.
— — var. amphiceros *Ehrbg.*, 236.
— — var. dimidiatus *Bryce*, mentd., 236, 237.
— — var. inermis *Schm.*, 236.
— — var. quartaria *de Beauchamp* *, 236.
— — var. spinosa *Wierz.*, 236.
— *patulus* Müll., 238.
— plicatilis *Müll.*, 238; mentd., 236.
— tetracanthus *Collin*, mentd., 236.
— tridens *Hood*, mentd., 235.
— *tridentatus* Herm., 238.
— urceolaris *Ehrbg.* var. rubens *Ehrbg.*, 238.
— urceus (*Linn.*), 466; mentd., 470, 471.
Brachynotus lucasi, mentd., 490.
Breda quinquedentata *Badcock* *, 4, 42.
British Guiana, Reports of the Cambridge Expedition, 1933. Illumination in the rain forest at ground level (Carter), 579–589.
Bufo regularis *Reuss*, 213, 219.
— vittatus *Blgr.*, 219.
Bufolucilia Towns., 395.
— *bufonivora* (Mon.) Towns., 419.
— *silvarum* (Mg.) Towns., 418.
Bulimina †, 555.
Buliminella *Cushm.*†, 555.
Buthus acutecarinatus *Simon*, 92.
— crassicauda (*Olivier*), 92.
— quinquestriatus (*Hempr. & Ehrbg.*), 91.

Caesariceps Rohd., 395.
— *flavipennis* (Kram.), 403.

Calanus, mentd., 368.
Calcarina sp.†, 568.
— spengleri (*Linn.*) †, 568.
Calephorus compressicornis (*Latr.*), 591, 605.
Callianassa stebbingi *Borrad.*, mentd., 545.
Calliphora, mentd., 390.
— *longilobata* Pand., 414.
— *simulatrix* Pand., 402.
Calman, W. T., communication by (Boschma), 473.
Calothrix sp., 266; mentd., 251–254, 274.
— brevissima *G. S. West* var. moniliformis *Ghose*, 266.
Cambridge Expedition to British Guiana, 1933. *See* Carter, G. S.
Cambridge Expedition to the East African Lakes, 1930–31, scientific results, 99–362.
Camponia lineata *Badcock* *, 4, 40.
Cancer pagurus *Linn.*, mentd., 515.
Cancris auricula (*Ficht. & Moll*) †, 567.
Cannula sulcata *Sjöst.*, 601.
Carcinides maenas (*Linn.*), mentd., 489, 490.
Carcinus maenas, mentd., 546.
Caridina, mentd., 351.
— africana *Kingsl.*, 356, 357; mentd., 351.
— — var. aegyptiaca, mentd., 358.
— — var. typica, mentd., 358.
— brevirostris, mentd., 357.
— nilotica (*Roux*), 351, 352; mentd., 357, 358.
— — var. natalensis, mentd., 352.
— — var. typica, mentd., 352, 354, 355, 357.
Carpenteria *balaniformis* Gray var. *proteiformis* Goës †, 572.
— proteiformis *Goës* †, 572.
— rotaliformis *Chapm. & Crespin* †, 572.
Carter, G. S., communications by (Badcock), 1; (Kreis), 55; Reports of the Cambridge Expedition to British Guiana, 1933. Illumination in the rain forest at ground level, 579–589.
Cassidulina *d'Orb.*†, 555.
— delicata *Cushm.*†, 560.
— *parkeriana* Heron-Allen & Earland †, 560.
Cassidulinoides *Cushm.*†, 556.
Cassidulinoides chapmani *Parr* †, 560.
Cataloipus pulcher *Sjöst.*, mentd., 614.
— — abyssinicus *Uv.**, 592, 593, 614.
Catantops melanostictus *Schaum.*, 612.
Caudina, mentd., 189.
Ceratium, mentd., 470.
— hirundinella, mentd., 251, 465, 466, 470.
Ceratobulimina *Toula* †, 555.
— hauerii (*d'Orb.*) †, mentd., 559.
— — var. australis *Cushm. & Harris* †, 559.
Ceratophyllum, mentd., 139, 170, 172, 175, 176.
— demersum, mentd., 179, 194.
Cercidia versicolor Keys., 23.
Ceriodaphnia, mentd., 180, 189, 195.
Chacoca antherata *Badcock* *, 3, 10.
— distincta *Badcock* *, 3, 11.
— flavodorsata *Badcock* *, 3, 11.
Chamaeleon bitaeniatus bitaeniatus *Fischer*, 227.
— — höhneli *Steind.*, 227.
— — rudis *Blgr.*, 227.
— — schubotzi *Sternf.*, 227, 228.
Chaoborus, mentd., 200.
Chapman, F., Parr, W. J., and Collins, A. C., Tertiary Foraminifera of Victoria, Australia.—The Balcombian Deposits of Port Phillip. Part III., 553–577.
Chiromantis petersi *Blgr.*, 217; mentd., 214.
Chlorogaster, 478; mentd., 475.
— *longissimus* Guérin-Ganivet, 479.
— sulcatus (*Lillj.*), 479; mentd., 478.
Chlorophis heterolepidotus (*Günther*), 219.
— irregularis (*Leach*), 219.
Chromogaster ovalis (*Berg.*), 466; mentd., 470.
— testudo *Lauterb.*, 466; mentd., 470.
Chroococcus minutus *Kütz.*, 266; mentd., 253.
Chrotogonus spp., 609.
Chrysomyia, mentd., 390.
— *capensis* R.-D., 411.
Cibicides dutemplei (*d'Orb.*) †, mentd., 571.
— lobatulus (*Walk. & Jacob*) †, 570.
— praecinctus (*Karrer*) †, mentd., 571.
— pseudoungerianus *Cushm.*†, mentd., 571.

Cibicides sorrentae *Chapm., Parr & Collins* † *, 572.
— ungerianus (*d'Orb.*) †, 571.
— victoriensis *Chapm., Parr & Collins* † *, 571.
Cichlid Fishes from the East African Lakes (Trewavas), 309–341.
Citharinus citharus (*Geoffr.*), mentd., 123.
— — subsp. intermedius *Worthington* *, 123.
— latus, mentd., 123.
Clarias, mentd., 153, 192, 200, 202, 208.
— lazera, mentd., 145.
Clavulina *d'Orb.*†, 557.
— textularioidea †, 557.
Clistosaccus, mentd., 537.
Closterium Kützingii *Bréb.*, 257; mentd., 254, 255.
Cocks, F. E., *see* Griffiths, B. Millard.
Coelastrum cambricum *Arch.*, 257.
— — var. rugosum *Rich*, 257; mentd., 255.
Coelosphaerium, mentd., 250.
— Goetzei *Schmidle*, 266; mentd., 254.
— Kutzingianum *Naeg.*, 266; mentd., 252.
— minutissimum *Lemmerm.*, 266; mentd., 252, 255.
Coelostoma *Brullé*, 303.
— rufitarse *Boh.*, mentd., 303.
Collins, A. C., *see* Chapman, F.
Collotheca, mentd., 469.
— campanulata *Dobie*, 466.
— mutabilis (*Huds.*), 466; mentd., 469.
Coluber florulentus, mentd., 220.
— keniensis *Parker* *, 220.
— smithi (*Blgr.*), 219; mentd., 214.
— tchadensis (*Chabanaud*), 220.
Colurella adriatica *Ehrbg.*, 466.
— colurus (*Ehrbg.*), 466.
Compsomyia, mentd., 390.
Conipoda gracilis *Mill.*, 609.
Conocephalus conocephalus (*Thunb.*), 599.
Conochiloides, mentd., 469.
— dossuarius *Huds.*, 241, 467; mentd., 469.
Conochilus, mentd., 469.
— hippocrepis (*Schrank*), 467.
— unicornis *Rouss.*, 467.
Cornuspira *Schultze* †, 556.
Corophium volutator (*Pall.*), mentd., 383.
Cosmarium granatum *Bréb.*, 257.
— humile (*Gay*) *Nordst.*, 257; mentd., 255.
Cosmarium sexangulare *Lund* f. minima *Nordst.*, 258; mentd., 254.
Cristellaria spp.†, 554.
Crocodilus niloticus *Laur.*, 229, mentd., 213.
Crucigenia quadrata *Morren*, 256; mentd., 253.
— rectangularis (*A. Br.*) *Gay*, 256; mentd., 252.
Crustacea Macrura (Prawns) from the East African Lakes (Gordon), 351–362.
Cryptomonas ovata *Ehrbg.*, 264; mentd., 254.
Cryptopodia fornicata (*Fabr.*), mentd., 511.
Cyatholaimus tenax de Man, 75.
Cybister *Curt.*, 302.
— tripunctatus *Ol.*, mentd., 302.
Cyclops, mentd., 170, 180, 189, 195.
Cyclotella, mentd., 189, 190.
— Meneghiniana *Kütz.*, 259; mentd., 253, 254.
Cymbella grossestriata *O. Müll.* var. obtusiuscula *O. Mull.*, 260; mentd., 253.
— helvetica *Kutz.*, 261; mentd., 253.
— ventricosa *Kutz.*, 262; mentd., 254.

Dactylococcopsis rhaphidioides *Hansg.*, 266.
Daphnia, mentd., 180, 195.
Dasylucilia Rohd., 395.
Dasypeltis scaber (*Linn.*), 220.
Dennell, R., The habits and feeding mechanism of the Amphipod Haustorius arenarius *Slabber*, 363–388.
Dentalina *d'Orb.*†, 554.
Diaphanosoma, mentd., 180, 189.
Diaptomus, mentd., 177, 180, 188, 189, 192, 205, 206.
Diaschiza forficata (*Ehrbg.*), 467.
— gibba (*Ehrbg.*), 467.
— sterea (*Gosse*), 467.
— ventripes *Dixon Nuttall*, 467.
Dicranophorus auritus (*Ehbrg.*), 467.
Dictyosphaerium pulchellum *Wood*, 256; mentd., 253, 255.
Dineutes *Macleay*, 302.
— aereus (*Klug*), mentd., 302.
Dinobryon, mentd., 250.
Dinocharis, mentd., 235.

Dinocharis (Trichotria) tetractis *Ehrbg.*, 232.
Dinotherium hobleyi †, mentd., 437, 441.
Diplodontus americanus *Marsh.*, mentd., 289.
— despiciens (*O. F. Müll.*), 289.
— — capensis *Viets*, mentd., 289.
— peregrinus *Koen.*, mentd., 289.
— perreptans *Viets*, mentd., 289.
— tenuipes *Koen.*, mentd., 289.
— trigonometricus *Walt.*, mentd., 289.
Diptychus sp., mentd., 547, 549.
Discorbina bertheloti (d'Orb.) †, 561.
— *globularis* (d'Orb.) †, 562.
— *lingulata* Burrows & Holland †, 564.
— *wilsoni* Heron-Allen & Earland †, 564.
Discorbis balcombensis *Chapm., Parr & Collins* † *, 562.
— bertheloti (*d'Orb.*) †, 561.
— — var. complanata †, mentd., 561.
— — var. papillata *Chapm., Parr & Collins* †, 561.
— disparilis †, mentd., 561.
— globularis (*d'Orb.*) †, 562.
— involuta †, mentd., 561.
— opercularis (*d'Orb.*) †, 562.
— planoconcava (*Chapm., Parr & Collins*)†, 561.
— *tuberculata* Heron-Allen & Earland †, 563.
— tuberculata (*Balkwill & Wright*) var. australiensis *Chapm., Parr & Collins*†*, 563.
— vesicularis, mentd., 563.
Dissotrocha aculeata *Ehrbg.* var. medio-aculeata *Janson*, 241.
Diurella brachyura (*Gosse*), 467.
— porcellus (*Gosse*), 467; mentd., 470.
— stylata *Eyferth*, 467; mentd., 470.
Dorylaimus *africanus* Daday, 76.
— annulatus *Daday*, 56, 82; mentd., 84, 87.
— *attenuatus* de Man, 76.
— *bastiani* Bütschli, 76.
— — f. *longicaudatus* (Daday) Micol., 76.
— filiformis *Bastian* f. longicaudatus (*Daday*), 56, 57, 76; mentd., 82.
— — f. typicus *Micol.*, 56, 75.
— — — sf. attenuatus (*de Man*), 56, 76.
— homalopapillatus Kreis *, 55, 56, 84.
— *longicaudatus* Daday, 76.
— *macrurus* Linst., 76.
— paraguayensis Kreis *, 55–57, 80.
Dorylaimus *pusillus* Daday, 76.
— stagnalis *Dujard.*, 56, 75.
— — subsp. secundus v. multipapillatus *Micol.*, mentd., 75.
— *tenuicaudatus* Bastian, 76.
— *tripapillatus* Daday, 87.
— unipapillatus (*Daday*), 56, 77.
Dossenus marginatus *Simon*, mentd., 35.
— marginellus *Badcock* *, 4, 35.
Drepanorchis, mentd., 499.
— neglecta (*Fraisse*), 537.
Drilocrius sp., mentd., 145, 347, 348, 350.
Dryopithecus †, mentd., 444, 445, 455–462.
— cautleyi †, mentd., 458.
— chinjiensis *Pilgr.*†, mentd., 455.
— darwini *Abel* †, mentd., 445, 455.
— fontani *Lartet* †, mentd., 455, 458, 462.
— frickae †, mentd., 458.
— giganteus *Pilgr.*†, mentd., 455.
— mogharensis †, mentd., 457, 461.
— pilgrimi †, mentd., 444, 457, 458.
— punjabicus *Pilgr.*†, 446, 447; mentd., 455, 456, 458, 462.
— rhenanus (*Pohlig.*) †, mentd., 445, 455, 456, 462.
Duronia tricolor (*Karny*), 602.
Dyocibicides biserialis *Cushm. & Valentine* †, 572.
Dyrinoides minutus *Badcock* *, 4, 34.
— onychiatus *Badcock* *, 4, 33; mentd., 34.

East African Lakes, Scientific results of the Cambridge Expedition, 1930–31.— 1. General introduction and station list (Worthington), 99–119; 2. Fishes other than Cichlidae (Worthington), 121–134; 3. The bionomics of some East African Swamps (Beadle), 135–155; 4. The waters of some East African Lakes in relation to their fauna and flora (Beadle), 157–211; 5. Reptiles and Amphibians (Parker), 213–229; 6. Rotifères et Gastrotriches (de Beauchamp), 231–248; 7. The Algae (Rich), 249–275; 8. Hydracarina (Lundblad), 277–296; 9. Leeches (Moore), 297–299; 10. Aquatic Coleopterous Larvae (Imms), 301–307; 11. The Cichlid Fishes

(Trewavas), 309–341; 12. Aquatic Heteroptera (Jaczewski), 343–346; 13. Adaptation to aerial respiration in Alma emini *Mich.*, an Oligochaet from East African swamps (Beadle), 347–350; 14. Crustacea Macrura (Prawns) (Gordon), 351–362.
Echis carinatus (*Schneid*), 221; mentd., 213.
Ehrenbergina *Reuss* †, 556.
Eleutherotheca concolor Karny, 604.
— *elegans* Karny, 604.
Ellipsolagena *A. Silvestri* †, 556; mentd., 554.
Engraulicypris bottegi, mentd., 128.
— minutus, mentd., 128.
— stellae *Worthington* *, 128.
Enithares sobria (*Stål*), 343.
Enoplochilus obtusicaudatus *Kreis* *, 55, 56, 72.
Entomological Expedition to Abyssinia, 1926–7: Orthoptera of the families Mantidae, Gryllidae, Tettigoniidae, and Acrididae (Uvarov), 591–614.
Eosphora melandocus (*Gosse*), 467.
Epeira deliciosa Keys., 23.
— *gregalis* Cambr., 23.
Eperua falcata *Aubl.*, mentd., 585.
Epiphanes, mentd., 233.
Epistomina elegans (*d'Orb.*) †, 567.
Epithemia zebra *Ehrbg.* var. porcellus *Grun.*, 262; mentd., 254.
Eponides concentricus (*Parker & Jones*) †, 565.
— repandus (*Ficht. & Moll*) †, 565.
Eremias spekii sextaeniata *Stejneger*, 225; mentd., 214.
Eretes *Cast.*, 301.
— australis *Er.*, mentd., 302.
— sticticus (*Linn.*), 302.
Eretmia, mentd., 246.
— cubeutes, mentd., 246.
— tetrathrix, mentd., 246.
— trithrix, mentd., 247.
Eriphia laevimana *Latr.*, mentd., 504–507.
— scabricula *Dana*, mentd., 504, 507.
Eristalis, mentd., 200, 201.
Ethusina abyssicola *S. I. Smith*, mentd., 518, 519.
— gracilipes var. robusta *Miers*, mentd., 515, 518, 519.
Eubrianax *Kiesw.*, 304.
Eubrianax edwardsi, *Lec.*, mentd., 304.
Euchlanis dilatata *Ehrbg.*, 467; mentd., 470.
— (Dipleuchlanis) propatula *Gosse*, 232.
— pyriformis *Gosse*, 467.
Eudactylota eudactylotum *Gosse*, 232.
Eudorina, 466.
Euglena acus *Ehrbg.*, 264; mentd., 255.
— oxyuris *Schm.* f. minor *Defldr.*, 264.
Euglypha, mentd., 246.
Eupagurus alaskensis *Benedict*, mentd., 481.
— bernhardus (*Linn.*), mentd., 474, 479.
— cuanensis (*Thomps.*), mentd., 479.
— excavatus (*Herbst*), mentd., 474, 479.
Euscyrtus maculipennis *Chop.*, 596.
Eustala anastera *Walk.*, mentd., 21.
— tribrachiata *Badcock* *, 3, 20.
— tridentata (*C. Koch*), mentd., 20.
Euterpe edulis *Mart.*, mentd., 585.

Faureia coerulescens *Mill.*, 605.
— *milanjica* (Karsch) var. *coerulescens* Mill., 605.
— rosea *Uv.*, mentd., 605.
Filinia brachiata (*Rouss.*), 467; mentd., 469.
— longiseta (*Ehrbg.*), 467; mentd., 470.
— passa (*Mull.*), 467.
Finnegan, S., Report on the Scorpions collected by Mr. Bertram Thomas in Arabia, 91–98.
Fishes, other than Cichlidae, of the East African Lakes (Worthington), 121–134.
Flabellina *d'Orb.*†, 554.
Floscularia sp., 241.
Foraminifera, tertiary, of Victoria, Australia.—The Balcombian Deposits of Port Phillip. Part III. (Chapman, Parr & Collins), 553–577.
Francilia Snn., 392, 395, 398.
— *alaskensis* Snn., 398.
Fresh-water Nematoda from the Paraguayan Chaco (Kreis), 55–90.
Frondicularia *Defrance* †, 554.
Frontipoda, mentd., 284–286.

Galathea intermedia *Lillj.*, mentd., 476, 545, 546.
— nexa *Embl.*, mentd., 476, 545, 546.

Galathea strigosa (*Linn.*), mentd., 475.
Galatheascus, 475.
— minutus *Boschma* *, 476.
— striatus *Boschma*, 475; mentd., 476, 478.
Gammarus, mentd., 384–386.
— locusta, mentd., 369, 370, 383, 387.
Garstang, W., communication by (Dennell) 363.
Gasteracantha cancriformis (*Linn.*), 3, 27.
Gastrimargus africanus *Sauss.*, 607.
— brevipes *Sjöst.*, 607.
— rothschildi *I. Boliv.* subsp. montanus *Uv.**, 592, 593, 607.
Gastropus stylifer *Imhof*, 467; mentd., 469, 470.
Gastrotriches from the East African Lakes (de Beauchamp), 231–248.
Gaudryina *d'Orb.*†, 557.
— siphonella †, 557.
Georgella incerta (*Koen.*), 289.
Glandulina *d'Orb.*†, 555.
Globigerina bulloides *d'Orb.*†, 569.
Globorotalia dehiscens *Chapm., Parr & Collins* † *, 569.
— scitula (*Brady*) †, 570.
Gloeocystis gigas (*Kütz.*) *Lagerh.*, 255; mentd., 252.
Gloeotrichia natans (*Hedw.*) *Rabenh.*, 267.
Glossiphonia conifera *Moore* *, 297.
— fusca *Castle*, mentd., 297.
— nilotica *Johans.*, 299.
— stuhlmanni *Blanch.*, 299.
— tricarinata *Blanch.*, 299.
— weberi *Blanch.*, 298.
Gomphocymbella Bruni (*Fricke*) *O. Mull.*, 260; mentd., 253, 254.
Gomphonema brachyneura *O. Müll.*, 260; mentd., 254.
— intricatum *Kütz.*, 260; mentd., 253, 254.
Gomphosphaeria aponina *Kütz.*, 266; mentd., 252.
Gonoplax angulata (*Penn.*), mentd., 519, 520.
Gordon, I., Crustacea Macrura (Prawns) from the East African Lakes (Cambridge Expedition), 351–362.
Grapsisaccus benedeni Kossm., 490.
— *benedeni* Stebb., 489.
Grapsus maculatus (*Catesby*), mentd., 529, 532.
Grapsus strigosus (*Herbst*), mentd., 524, 532.
Griffiths, B. Millard, and Cocks, F. E., Studies in the Phytoplankton of the Lowland Waters of Great Britain.—No. VI. The Rotifer Fauna associated with the Phytoplankton of twenty-eight Lowland Waters, 465–471.
Gryllotalpa africana (*Beauv.*), 593.
Gryllus brunneri *Selys*, 594.
— burdigalensis *Latr.*, 594.
— confirmatus *Walk.*, 594.
— conspersus *Sch.*, 594.
Guttulina *d'Orb.*†, 555.
Gymnobothrus inflexus *Uv.**, 603.
— linea-alba *I. Boliv.*, 603.
Gymnodinium sp., 264; mentd., 255.

Haplochilichthys analis *Worthington* *, 130.
— antinorii *Vincig.*, 132; mentd., 130, 141.
— myaposae *Blgr.*, mentd., 132.
— pelagicus *Worthington* *, 129.
— pumilus (*Blgr.*), 132.
— rudolfianus *Worthington* *, 131.
— schoelleri *Blgr.*, mentd., 132.
— stuhlmanni *Ahl.*, mentd., 131.
Haplochromis *alluaudi* Blgr., 321.
— angustifrons *Blgr.*, 313, 327, 334; mentd., 332, 337, 338.
— annectidens *Trew.**, 312, 323; mentd., 311.
— beadlei *Trew.**, 312, 324; mentd., 311.
— chilotes, mentd., 311, 336.
— cinereus, mentd., 311, 323, 330, 331, 333.
— crassilabris, mentd., 311, 325, 336.
— dolorosus *Trew.**, 313, 327, 338.
— eduardii *Regan*, 313, 327, 332; mentd., 333, 334.
— elegans *Trew.**, 313, 327, 332.
— engystoma *Trew.**, 313, 327, 331.
— fuscus *Regan*, 313, 326, 329.
— gestri, mentd., 323.
— graueri, mentd., 310.
— guiarti (*Pellgr.*), 313, 327, 339.
— ishmaeli *Blgr.*, 313, 327, 334; mentd., 311.
— labiatus *Trew.**, 313, 327, 335; mentd., 311.
— limax *Trew.**, 313, 326, 328.

Haplochromis macrops (*Blgr.*), 313, 327, 333; mentd., 310, 328, 331.
— martini, mentd., 310.
— melanopus, mentd., 332.
— mentatus *Regan*, 313, 327, 339.
— multicolor (*Hilgendorf*), 312, 326, 329; mentd., 310, 311.
— nigrescens, mentd., 311.
— nigricans, mentd., 328.
— nigripinnis *Regan*, 313, 326, 330
— nubilus (*Blgr.*), 312, 313, 326, 329; mentd., 311, 323.
— nuchisquamulatus, mentd., 311, 328.
— obliquidens, mentd., 311, 324.
— pappenheimi (*Blgr.*), 313, 327, 334; mentd., 332.
— paucidens, mentd., 311.
— pellegrini *Regan*, 312, 326.
— plagiodon, mentd., 311, 324.
— rudolfianus *Trew.**, 312, 321.
— sauvagei, mentd., 311, 325, 336.
— schubotzi *Blgr.*, 313, 327, 337; mentd., 323, 335.
— *schubotzi* (part.) Regan, 331, 332, 334, 337.
— serranus, mentd., 310, 338.
— serridens *Regan*, 313, 326, 327; mentd., 311.
— *spekii* (part.) *Blgr.*, 310, 334.
— squamipinnis *Regan*, 313, 327, 338, mentd., 339.
— *strigigena* (part.) Blgr., 329.
— taurinus *Trew.**, 313, 327, 336.
— velifer *Trew.**, 312, 322; mentd., 324.
— vicarius *Trew.**, 313, 327, 330; mentd., 328, 332, 334.
Haplophragmium †, 557.
Haustorius arenarius *Slabber*, habits and feeding mechanism (Dennell), 363–388.
Helochares *Muls.*, 304.
— consputus *Boh.*, mentd., 304.
Helotrephes hungerfordi *Esaki & China*, 346.
Hemicristellaria *Stache* †, 554.
Hemidactylus brookii *Gray*, 223; mentd., 213.
— isolepis *Blgr.*, 223; mentd., 214.
Hemimysis, mentd., 375, 382, 384, 386.
Hemipyrellia, mentd., 391.
— ligurriens (*Wied.*), mentd., 407, 409.
Hemiscorpio hierochonticus Simon, 91.
Herminiera elaphroxylon, mentd., 179.
Heronallenia lingulata (*Burrows & Holland*) †, 564.
— wilsoni (*Heron-Allen & Earland*) †, 564.
Heteroptornis minuta *Uv.**, 592, 608.
Heterostomella *Reuss* †, 557.
Hirudo sp., 299.
— hilderbrandti *Blanch.*, 299.
Homoeogryllus reticulatus (*F.*), 595.
Homorocoryphus nitidulus (*Scopoli*), 599.
Homotrema †, mentd., 573.
Hopwood, A. Tindell, Miocene Primates from Kenya, 437 464.
Hora, S. L., communication by (Lele), 49.
Hormidium, mentd., 166, 188–190.
— subtile (*Kutz.*) *Heering*, 257; mentd., 250, 252, 253, 271.
Hormiscia subtilis (*Kutz.*) *De Toni* var. variabilis (*Kutz.*) *Kirchn.*, mentd., 257.
Humbe tenuicornis (*Schaum*), 607.
Hyas, mentd., 515.
Hydracarina from the East African Lakes (Lundblad), 277–296.
Hydrachna (Rhabdohydrachna) bisignifera *Viets* f. worthingtoni *Lundbl.**, 280.
— dividua *Walt.*, mentd., 280.
— fissigera *Koen.*, mentd., 280.
— (Monohydrachna) inaequiscutata *Lundbl.**, 277.
— junodi *Walt.*, mentd., 286.
— mertoni *Walt.*, mentd., 277.
— rimosa *Walt.*, mentd., 280.
— signata *Koen.*, mentd., 280.
— spinosa *Koen.*, mentd., 280.
Hydrachnida, mentd., 170.
Hydriphantes incertus Daday, 289.
Hydrocotyle, mentd., 137.
Hydrometra sp., 343.
Hydrophilus *Leach*, 303.
Hydrovatus *Motsch.*, 301.
Hydryphantes incertus Koen., 289.
Hylobates, 438–440; mentd., 461.
— leuciscus, 438, 439.
Hyperolius cinctiventris *Cope*, 217.
— picturatus *Peters*, 217.
— striolatus *Peters*, 219.
— stuhlmanni *Ahl*, 219.
— taeniatus *Peters*, mentd., 219.
Hyphydrus *Ill.*, 301.
— cycloides *Rég.*, mentd., 301.

Imms, A. D., On some Aquatic Coleopterous Larvae from the East African Lakes (Cambridge Expedition), 301–307.
Inachus mauritanicus *Lucas*, mentd., 537, 538.
Iyengar, M. O. P., Contributions to our knowledge of the Colonial Volvocales of South India [Title only], 472.

Jaculella *Brady* †, 556.
Jaczewski, T., Aquatic Heteroptera from the East African Lakes (Cambridge Expedition), 343–346.

Keratella cochlearis (*Gosse*), 467; mentd., 465, 469–471.
— *quadrata* Müll., 238, 467, 469–471.
— serrulata (*Ehrbg.*), 467; mentd., 469.
Kijanebalola dubia *de Beauchamp* *, 241.
Kirchneriella lunaris (*Kirchn.*) *Möbius*, 256; mentd., 253.
— obesa (*West*) *Schmidle*, 256; mentd., 252.
Koonunga, mentd., 385.
Kreis, H. A., Fresh-water Nematoda from the Paraguayan Chaco, 55–90.

Lacinularia, 240.
Lagena *Walk. & Jacob* †, 554.
— schlichti †, mentd., 554, 556.
Lambrus contrarius (*Herbst*), mentd., 538.
— longimanus *Linn.*, mentd., 483.
— validus *de Haan*, mentd., 507.
Latastia longicaudata revoili (*Vaill.*), 226; mentd., 214.
Lates albertianus, mentd., 133.
— macrophthalmus, mentd., 133.
— niloticus (*Linn.*), 133.
— — subsp. longispinis *Worthington* *, 134.
— — subsp. rudolfianus *Worthington* *, 133.
Latrodectus carteri *Badcock* *, 3, 12.
— cretaceus *Badcock* *, 3, 13.
— curacaviensis (*Müll.*), 3, 13.
Lecane, mentd., 231.
— depressa (*Bryce*), 467.
— flexilis (*Gosse*), 467.
Lecane ligona (*Dunlop*), 467; mentd., 469.
— luna (*Müll.*), 232, 467; mentd., 470.
Leeches from the East African Lakes (Percy Moore), 297–299.
Lele, S. H., The circulation of blood in the air-breathing chambers of Ophiocephalus punctatus *Bloch*, 49–54.
Lemna, mentd., 146.
Lenticulina *Lamarck* †, 554.
Lepadella ovalis (*Müll.*), 467.
— patella (*Müll.*), 232, 467; mentd., 470.
Lepidactylus Say, 363.
Leptacris violacea (*Karny*), 611.
Leptodius exaratus, mentd., 490.
Leptotyphlops fiechteri (*Scortecci*), 219; mentd., 214.
Lernaeodiscus, mentd., 475, 544, 545.
— galatheae (*Norman & Scott*), 545; mentd., 473.
— munidae (*Smith*), 545.
— porcellanae *Müll.*, mentd., 545.
Leucauge atrostricta *Badcock* *, 3, 14.
— volupis *Keys.*, mentd., 14.
Limnatis oligodonta *Johans.*, 299.
Limnesia aspera *Koen.* subsp. macropora *Viets*, 291.
Limnias annulatus *Bailey*, 241.
— *melicerta* Weisse, 241.
Limnopithecus †, 438, 461; mentd., 444, 462.
— legetet *Hopwood* †, 438.
Lingulina *d'Orb.*†, 554.
Liogryllus morio (*F.*), 594.
Lituola *Lamarck* †, 557.
Locusta migratoria migratorioides (*Reiche & Fairmaire*), 607.
Loxothylacus, mentd., 499.
— aristatus *Boschma*, 538.
— desmothrix, mentd., 541.
— setaceus, mentd., 541.
— spinulosus *Boschma*, 541.
Lucilia *R.-D.* (Diptera, Calliphoridae), revision of the genus (Aubertin), 389–436.
— alaskensis (*Snn.*), 396, 398; mentd., 394.
— *albopilosa* S.-W., 406.
— *amica* R.-D., 412.
— ampullacea *Vill.*, 396, 403; mentd., 392, 402.
— *angustifrons* Towns., 400.
— *argyricephala* Macq., 413.
— *australis* Towns., 421.
— azurea *R.-D.*, mentd., 424.

Lucilia *azurea* Dol., 406.
— *barberi* Towns., 411, 412.
— *basalis* Macq., 411, 412.
— *brunnicornis* Macq., 426.
— *brunnicosa* R.-D., 418, 419.
— bufonivora *Mon.*, 397, 419; mentd., 393, 394.
— caeruleiviridis *Macq.*, 397, 421.
— caesar (*Linn.*), 395, 396, 400; mentd., 390, 392–394, 402–404, 409, 424.
— *caesar* Hough, 402.
— *caesar* Howard, 402.
— *caesar* Johns., 402.
— *caesar* Snn., 402.
— *caesar* Tothill, 402.
— *caesar* Towns., 402.
— *calviceps* Bezzi, 406, 407.
— cluvia (*Walk.*), 397, 418; mentd., 422.
— *consobrina* Macq., 402.
— *craggii* Patton, 408.
— cuprina (*Wied.*), 397, 412, mentd., 393, 394.
— *cyaneo-marginata* Macq., 406.
— *ditissima* Bezzi, 399.
— *dorsalis* R.-D., 412.
— *elegans* R.-D., 413.
— *elongata* Snn., 419, 421.
— eximia (*Wied.*), 398, 423; mentd., 394, 395, 424–426.
— *flavicornis* Mall., 410.
— *flavipennis* Kram., 403.
— *flavipennis* Macq., 411, 412.
— *fraterna* Macq., 402.
— *frontalis* (Lw. & Br. & von B.), 411.
— fumicosta *Mall.*, 396, 399.
— *giraulti* Towns., 411, 412.
— graphita *Snn.*, 396, 410; mentd., 394.
— *hirtiforceps* Snn., 423.
— ibis *Snn.*, 398, 424; mentd., 395.
— illustris (*Mg.*), 396, 402; mentd., 393, 394, 404, 422.
— infernalis (*Vill.*), 396, 404; mentd., 392.
— — var. caerulea (*Ség.*), 396, 405.
— *infuscata* Towns., 422.
— *krameri* Ség., 403.
— *lepida* R.-D., 402.
— *leucodes* Frauenf., 413, 414.
— mexicana *Macq.*, 398, 422.
— (*Lucilia*) *nigricosta* Mall., 392, 405.
— *nigripalpis* Towns., 418, 419.
— *nosocomiorum* Dol., 406, 407.
Lucilia ochricornis (*Wied.*), 398, 425; mentd., 394, 424.
— *ocularis* Snn., 426, 427.
— *oculata* Towns., 421.
— *pallescens* Snn., 413.
— papuensis *Macq.*, 396, 406; mentd., 394, 407, 408.
— *parvula* (Mg.), 403.
— *pilatei* Hough, 418.
— pilosiventris *Kram.*, 397, 415; mentd., 417.
— *pilosiventris* Richards, 416.
— pionia (*Walk.*), 396, 399; mentd., 394.
— porphyrina (*Walk.*), 396, 408; mentd., 394, 407, 409, 410.
— — var. flavicornis *Mall.*, 397, 410.
— *praescia* G.-T., 426, 427.
— *problematica* Johns., 418.
— *punctipennis* Macq., 423.
— purpurascens (*Walk.*), 398, 426; mentd., 394, 395.
— *purpurea* Towns., 402.
— regalis (*Mg.*), 397, 414, mentd., 419.
— rica *Snn.*, 398, 424; mentd., 394, 395.
— richardsi *Collin*, 397, 416.
— *ruficornis* Macq., 423.
— *sayi* Jaen., 411.
— sericata (*Mg.*), 397, 411; mentd., 392–394, 413, 414, 422.
— silvarum (*Mg.*), 397, 418; mentd., 393, 394, 403, 420.
— sinensis *Aubertin* *, 396, 407.
— *splendida* Verr., 416.
— *subrectinevris* Macq., 425.
— thatuna *Snn.*, 397, 417.
— *unicolor* Towns., 422.
— *violacea* Macq., 426.
Luciliella Mall., 392, 395.
Luciola sp., 306.
Lundblad, O., Hydracarina from the East African Lakes (Cambridge Expedition), 277–296.
Lycosa albimarginata *Badcock* *, 4, 37.
— nanahuensis *Badcock* *, 4, 36
— nordenskioldi *Tullgr.*, mentd., 36.
Lygodactylus picturatus gutturalis *Bocage*, 223; mentd., 213.
Lygosoma sundevallii (*Smith*), 226; mentd., 214.
Lyngbya, mentd., 274.
— bipunctata *Lemmerm.*, mentd., 272.
— circumcreta *G. S. West*, 272; mentd., 251, 252, 254, 255, 274.

Lyngbya contorta *Lemmerm.*, mentd., 272–274.
— Hieronymusii *Lemmerm.*, 272.
— Lagerheimii (*Möbius*) *Gomont*, 273; mentd., 251, 253, 254, 272.
— limnetica *Lemmerm.*, 272; mentd., 255.
— lutea *Gomont* f. nov., 272; mentd., 252, 266, 267.

Mabuya brevicollis (*Wicg.*), 226; mentd., 213.
Macrophthalmus erato, mentd., 532.
Macropodia longirostris (*Fabr.*), mentd., **537, 538.**
— rostrata (*Linn.*), mentd., 537, 538.
Makthalia cincta *Badcock* *, 4, 45.
Manicole swamp, 585.
Marginulina *d'Orb.*†, 554.
Megalotheca sp., 599.
Megalotrocha, 240.
Melia tessellata, mentd., 547, 548.
Melosira, mentd., 166, 170, 171, 180, 190, 198.
— ambigua *O. Mull.*, 258; mentd., 252.
— granulata (*Ehrbg.*) *Ralfs*, 258; mentd. 250, 254, 255.
— — var. angustissima *O. Mull.*, 258; mentd., 250, 252, 255.
Merismopedia tenuissima *Lund*, 266; mentd., 254, 255.
Mesopithecus pentelici †, mentd., 444.
Mesovelia vittigera *Horv.*, 343.
Metazygia gregalis Cambr., 23.
Micippe mascaronica *Kossm.*, mentd., 501.
Micrathena silvicola *Badcock* *, 3, 27.
Microbuthus pusillus *Kraepelin*, 92.
Microchaete capensis *Hodgetts*, 267; mentd., 254.
— uberrima *N. Carter* f. minor *N. Carter*, 267; mentd., 254.
— violacea *Frémy*, mentd., 267.
Microcystis, mentd., 144, 166, 178, 180, 194, 195, 197, 198, 200, 204–206, 210.
— aeruginosa *Kütz.*, mentd., 251, 265.
— flos-aquae (*Wittr.*) *Kirchn.*, 265; mentd., 250–255, 271.
— marginata (*Menegh.*) *Kütz.*, 265.
Micronecta compar *Horv.*, 346.
— piccanin *Hutch.*, 346.
— quewalepele *Hutch.*, 346.
— ras *Hutch.*, 346.
Micronecta scutellaris (*Stål*), mentd., 346.
— youngiana *Hutch.*, 346.
Microthamnion strictissimum *Rabenh.*, 257.
Miliolina spp.†, 556, 557.
Millepora miniacea Pall.†, 573.
Miocene Primates from Kenya (Hopwood), 437–464.
Miomantis fallax *Giglio-Tos*, 593.
Mirandia australis *Badcock* *, 4, 47.
Misumena ignobilis *Badcock*, 4, 29.
— pulchra *Badcock* *, 4, 30.
— viridis *Badcock* *, 4, 29.
Moina, mentd., 170, **180, 189**, 195.
Monhystera annulifera *Daday*, 56, 61.
— paludicola *de Man*, 56, 61.
Monohydrachna, mentd., 286.
Monostyla, mentd., 231.
— bulla *Gosse*, 232.
— cornuta (*Mull.*), 467.
— lunaris (*Ehrbg.*), 467.
Monticolaria, mentd., 592.
Moore, J. Percy, Leeches from the East African Lakes (Cambridge Expedition), 297–299.
Mora forest, 585.
— excelsa *Bth.*, mentd., 585.
Mormyrus caschive *Linn.*, 122.
— kannume *Forsk.*, 122.
Morphacris fasciata (*Thunb.*), 609.
Mougeotia sp., 257; mentd., 251, 252, 254.
Mummucia dubia *Badcock* *, 4, 48.
— variegata *Gervais*, mentd., 48.
Musca, mentd., 390.
— *caesar* Linn., 390, 400.
— *cluvia* Walk., 418.
— *cuprina* Wied., 412.
— ditissima *Walk.*, mentd., 400.
— *equestris* Mg., 402.
— *eximia* Wied., 423.
— *fucina* Walk., 413.
— *illustris* Mg., 402.
— *inducta* Walk., 406.
— *inscribens* Walk., 406.
— *insularis* Walk., 423.
— *lagyra* Walk., 411.
— *marginifera* Walk., 406.
— *metilia* Walk., 406.
— *muralis* Walk., 402.
— *nitescens* Walk., 406.
— *nobilis* Mg., 411.
— *ochricornis* Wied., 423, 425.
— *parvula* Mg., 402.
— *pionia* Walk., 399.

Musca *porphyrina* Walk., 408.
— *purpurascens* Walk., 426.
— putrida *F.*, mentd., 424.
— *regalis* Mg., 414.
— *serenissima* Walk., 413.
— *sericata* Mg., 411.
— *silvarum* Mg., 418.
— *splendida* Mg., 400.
— *temperata* Walk., 413.
— *tifata* Walk., 406.
Mysis, mentd., 386.
Mytilina mucronata (*Mull.*), 467.
— ventralis *Ehrbg.*, 232, 467; mentd., 470.
— — var. brevispina *Ehrbg.*, 232.

Naias, mentd., 137.
Naja melanoleuca *Hallowell*, 221.
— nigricollis *Reinh.*, 221; mentd., 213.
Najas minor, mentd., 179.
Nanahua carteri *Badcock* *, 3, 5.
Nansonia brevicornis *Ashm.*, mentd., 393.
Nautilus auricula var. α Ficht. & Moll †, 567.
— *beccarii* Linn.†, 567.
— *lobatulus* Walk. & Jacob †, 570.
— *repandus* Ficht. & Moll †, 565.
Navicula cryptocephala *Kutz.*, 259; mentd., 253
— pupula *Kutz.*, 259; mentd., 253.
— salinarum *Grun.*, 260.
— (Anomoeoneis) sphaerophora (*Kutz.*) *Pfitzer* var. rostrata *Mull.*, 260; mentd., 253.
— vulpina *Kütz.*, 260; mentd., 254.
Nebalia, mentd., 386.
Nebo hierochonticus (*Simon*), 91.
Nematoda, Fresh-water, from the Paraguayan Chaco (Kreis), 55–90.
Neogossea, mentd., 244–247.
Nephila chacoensis *Badcock* *, 3, 16.
— clavipes *Linn.*, mentd., 16.
— dubia *Badcock* *, 3, 17.
Nephrocytium lunatum *West*, 255; mentd., 252.
Neptunus pelagicus, mentd., 547, 548.
Neritius abyssinicus *Uv.**, 592, 612.
— rothschildi, mentd., 614.
Nitzschia, mentd., 180, 195.
— communis *Rabenh.* var. perpusilla *Rabenh.*, 263; mentd., 254.
— hungarica *Grun.*, 264; mentd., 253.
Nitzschia microcephala *Grun.*, 264; mentd., 252, 254.
Nodosaria *Lamarck* †, 554.
— (Glandulina) laevigata †, 555.
Nodularia spumigena *Mertens*, 268; mentd., 254.
— — var. vacuolata *Fritsch & Rich*, mentd., 268.
Nonionina quinqueloba Reuss †, 568.
— *sphaeroides* d'Orb.†, 568.
Nostoc sp., 267; mentd., 251, 252, 266.
Noteus, mentd., 235.
— (Platyias) quadricornis *Ehrbg.*, 238.
Notholca foliacea (*Ehrbg.*), 467; mentd., 469.
— longispina (*Kellicott*), 467; mentd., 470.
— striata (*Mull.*), 467; mentd., 470.
Nothroctenus stupidus *Badcock* *, 4, 31.
Notommata cerberus *Gosse*, 232.
— copeus *Ehrbg.*, 232.
— cyrtopus *Gosse*, 467.
— pachyura (*Gosse*), 467.
— pseudocerberus *de Beauchamp*, 467.
Notopoides latus (*Henderson*), mentd., 520.
Notops brachionus, mentd., 234, 235.
— clavulatus, mentd., 235.
— *macrourus* Barrois & Daday, 233.
— (Epiphanes) mollis *Hempel*, 233.
— pelagicus *Hempel*, mentd., 233–235.
Nummulites variolaria Howchin †, 568.
Nychia limpida *Stål*, 345.
— — f. sappho *Kirk.*, 345.

Ocotea Rodioei (*Schomb.*) *Mez.*, mentd., 585.
Oecanthus rufo *Chop.*, 595.
— similis *Chop.*, 595.
Oecistes, 240.
Oedaleus cephalotes *Uv.**, 592, 606.
Oedogonium sp., 257; mentd., 251, 252, 254.
Oniscus arenarius Slabber, 363.
— *lucilioides* der Wulp, 418.
Ophiocephalus punctatus *Bloch*, the circulation of blood in the air-breathing chambers of (Lele), 49–54.
— *striatus*, 49, 51, 54.
Orbulina universa *d'Orb.*†, 569
Orectogyrus *Rég.*, 302.
— leroyi *Rég.*, mentd., 303.

Oreopithecus †, mentd., 444, 445.
Orthellia, mentd., 390.
Orthoptera of Entomological Expedition to Abyssinia, 1926–7 (Uvarov), 591–614.
Oscillatoria princeps *Vauch.*, 271.
— tenuis *Ag.*, 271; mentd., 254.
Oxya hyla (*Fabr.*), 612.
Oxyothespis brevicollis *Beier*, 593.

Pachygrapsus crassipes, mentd., 494.
— marmoratus, mentd., 490.
Pagurus striatus, mentd., 547, 549.
Palaemon, mentd., 351.
— moorei, mentd., 360.
— niloticus *Roux*, 359; mentd., 351.
Pandalina brevirostris (*Rathke*), mentd., 546, 547.
Pandorina, 466; mentd., 465, 470.
Pantolepta heteromorpha *Karsch*, 597.
Papyrus, mentd., 137, 139, 142, 143, 145, 146, 170, 179, 186, 194, 280, 284, 288, 289, 291.
Paracinema sp., 605.
— tricolor *Thunb.*, mentd., 605.
Paracomacris abyssinicus *Uv.**, 592, 601.
— deceptor *Karsch*, 602.
— elgonensis *Uv.*, mentd., 592, 601, 602.
— loveni *Sjöst.*, mentd., 592.
Paraguayan Chaco, Arachnida from (Badcock), 1–48; Fresh-water Nematoda from (Kreis), 55–90.
Paranaspides, mentd., 385.
Parapagurus, mentd., 547, 548.
Parasphena abyssinica *Uv.**, 592, 611.
— montana *Uv.**, 592, 609.
Paratilapia multicolor Hilgendorf, 329.
Parker, H. W., Reptiles and Amphibians from the East African Lakes (Cambridge Expedition), 213–229.
Parr., W. J., *see* Chapman, F.
Parthenopea, 544; mentd., 475.
— subterranea *Kossm.*, 545; mentd., 544.
Paspalidium geminatum, mentd., 179.
Patellina corrugata *Williamson* †, 560.
Pedalia intermedia *Wisz.*, 240.
— mira *Huds.*, 240, 467.
Pediastrum Boryanum, mentd., 465, 470.
— duplex *Meyen* var. reticulatum *Lagerh.*, 255; mentd., 253–255.
— simplex (*Meyen*) *Lemmerm.* var. radians *Lemmerm.*, 255; mentd., 253.
Pediastrum tetras (*Ehrbg.*) *Ralfs*, 255; mentd., 252.
Pelmatochromis caudifasciatus, mentd., 310, 321.
— exsul *Trew.**, 312, 320; mentd., 309.
— kribensis, mentd., 310, 321.
— *spekii* (part.) Blgr., 337.
Peltogaster, mentd., 475.
— curvatus *Kossm.*, 474; mentd., 478.
— *longissimus* Kossm., 478, 479.
— microstoma, mentd., 478.
— paguri *Rathke*, 474; mentd., 478.
— *sulcatus* Lillj., 478, 479.
Peltogasterella, 481.
— socialis *Krüger*, 481.
Peropyrrhicia cooperi *Uv.**, 592, 598.
— scotti *Uv.**, 592, 597; mentd., 598.
Phacus longicauda (*Ehrbg.*) *Duj.* var. torta, 264; mentd., 255.
— pleuronectes (*O. Mull.*) *Duj.*, 265; mentd., 252.
Phaenicia R.-D., 392, 395.
Phaeophilacris, mentd., 596.
Phaneroptera nana *Fieber*, 591, 596.
Philochortus intermedius subsp. rudolfensis *Parker* *, 226; mentd., 214.
Phlesirtes brachiatus *Uv.*, 592, 599.
Phormia, mentd., 390.
Phormidium, mentd., 166, 189, 190.
— ambiguum *Gomont*, 271; mentd., 255.
— autumnale (*Ag.*) *Gomont*, 271; mentd., 252, 253.
— foveolarum *Gomont*, 271.
— molle *Gomont*, 271; mentd., 253.
— mucicola *Naumann & Huber*, 271; mentd., 252.
— valderianum (*Delp.*) *Gomont*, 272; mentd., 252.
Phrynobatrachus *acridoides* Andersson, 217.
— kinangopensis (*Angel*), 217.
— natalensis (*A. Smith*), 216.
— ogoensis *Blgr.*, mentd., 217.
Phumonesia Vill., 395.
— *infernalis* Vill., 404.
— *villeneuvi* Curr., 405.
Phymateus pulcherrimus *I. Boliv.*, 611.
Physocyclus muricola *Badcock* *, 3, 7.
Pilumnus sp., mentd., 547, 548.
— seminudus, mentd., 541.
Pinnotheres, mentd., 499.
Piona angulata *Viets*, 292.
— caligifera (*Koen.*), mentd., 293–295.

Piona caligifera var. **worthingtoni** *Lundbl.**, 292.
— **forcipata** (*Koen.*), mentd., 292, 294.
— **longispina** *Viets*, mentd., 293, 294.
— **paucipora** (*Thor.*), mentd., 293, 294.
— **variabilis** *C. L. Koch*, mentd., 293–295.
Pisa armata (*Latr.*), mentd., 489, 490.
Pistia, mentd., 145, 179.
Placobdella fimbriata (*Johans.*), 299.
— **jaegerskioldi** (*Johans.*), 299.
Plagusia depressa, mentd., 532.
— — var. **immaculata**, mentd., 532.
Planispirina *Seguenza* †, 556.
Planulina biconcava (*Jones & Parker*) †, mentd., 561, 562.
— — var. *planoconcava* Chapm.†, 561.
Platypterna gracilis *Krauss*, 602.
Plea piccanina *Hutch.*, 345.
— **pullula** *Stål*, 345.
Plectus paraguayensis *Kreis* *, 56, 70.
— **tenuis** *Bastian*, mentd., 71.
Pleurotrocha petromyzon *Ehrbg.*, 467.
Plexippus albicrinitus *Badcock* *, 4, 43; mentd., 44.
— **luteus** *Badcock* *, 4, 44.
— **paykulli** (*Audouin*), 4, 42; mentd., 43.
Pliopithecus †, mentd., 440, 441.
— **antiquus** *Gervais* †, mentd., 440.
Ploesoma hudsoni (*Imhof*), 467; mentd., 469.
Pnorisa squalus *Stål*, 604.
Polyarthra euryptera *Wierz.*, 468; mentd., 469, 471.
— **platyptera** *Ehrbg.*, 232.
— ***trigla*** Ehrbg., 232, 468–471.
Polychaetus (**Macrochaetus**) **collinsi** *Gosse*, 232.
Polymorphina spp.†, 555.
— **elegantissima** †, 555.
— **glandulinoides** †, 555.
Polyspilota montana *Beier*, 592, 593.
Polytrema miniaceum (*Pall.*) †, 573.
— — var. **alba** *Carter* †, 573.
Polytrichum, mentd., 469.
Pompholyx, mentd., 470.
— **complanata** *Gosse*, 468.
— **sulcata** *Huds.*, 468.
Porphyrosiphon, mentd., 274.
— **Notarisii**, mentd., 274.
Portunascus corrugatus Giard, 490.
— ***corrugatus*** Stebb., 489.
Portunus arcuatus *Leach*, mentd., 489.
— **corrugatus**, mentd., 490.
— **holsatus** *Fabr.*, mentd., 489.
— **pusillus**, mentd., 489.
Potamogale, mentd., 437.
Potamogeton, mentd., 137, 139, 170, 171, 186.
Proales decipiens (*Ehrbg.*), 468.
Proconsul †, mentd., 444, 445.
— **africanus** *Hopwood* †, 445.
Prohylobates †, 461; mentd., 440, 441.
— **tandyi** *Fourteau* †, mentd., 440, 441.
Proichthydium, mentd., 244.
Propliopithecus †, 461, 462.
Proterendothrix scolecoidea *W. & G. S. West*, mentd., 266.
Protopterus, mentd., 153.
— **aethiopicus**, mentd., 145.
Psammophis biseriatus *Peters*, 221; mentd., 214.
Psecas pulchra *Badcock* *, 4, 39.
— **splendida** *Badcock* *, 4, 38.
— (**Thiania**) **sumptuosa** *C. Koch*, mentd., 38.
Psephenus, mentd., 304, 306.
Pseudocerastes, mentd., 222.
— **persicus**, mentd., 223.
Pseudoharpax abyssinicus *Beier*, 593.
Pterodina (**Testudinella**) **patina** *Herm.*, 240.
Pteronemobius fascipes *Walk.*, 594.
Pterygocera Latr., 363.
Ptychascus *Boschma* *, 532, 536; mentd., 473.
— **glaber** *Boschma* *, 532.
Ptygura crystallina (*Ehrbg.*), 468; mentd., 465.
Pullenia quinqueloba (*Reuss*) †, 568.
— **sphaeroides** (*d'Orb.*) †, 568.
Pulvinulina *auricula* (Ficht & Moll) †, 567.
— *concentrica* Parker & Jones †, 565.
— **hauerii** (*d'Orb.*) †, mentd., 559.
— *oblonga* Williamson †, 567.
— *patagonica* Brady †, 570.
— *repanda* (Ficht. & Moll) †, 565.
— *scitula* Brady †, 570.
Pulvinulinella †, mentd., 563, 566.
— **tenuimarginata** *Chapm., Parr & Collins* † *, 565.
Pyrellia, mentd., 390.
Pyrgo *Defrance* †, 557.
Pyrgomorpha cognata *Krauss*, 609.

Quinqueloculina *d'Orb.*†, 556.

Ramulina *Rupert Jones* †, 555.
Rana delalandii (*Dum. & Bibr.*), 216; mentd., 214.
— fuscigula *Dum. & Bibr.*, 216.
— galamensis *Dum. & Bibr.*, 216.
— mascareniensis *Dum. & Bibr.*, 216; mentd., 213.
Rapatea paludosa *Aubl.*, mentd., 585.
Raphidium falcatus Corda, 256.
Reptiles from the East African Lakes (Parker), 213–229.
Resticula melandocus *Gosse*, 232.
Rhabditis monhystera *Bütschli*, 56, 71.
— *simplex* Cobb, 71.
Rhabdolaimus *minor* Cobb, 72.
— terrestris *de Man*, 56, 57, 72.
Rhamphiophis rostratus *Peters*, 221; mentd., 214.
Rhizocephala in the collection of the British Museum (Boschma), 473–552
Rhizosolenia, mentd., 250.
Rhomphaea paradoxa *Tacz.*, mentd., 8.
— spinosa *Badcock* *, 3, 8.
Rhopalodia, mentd., 189, 190, 195, 250.
— ascoidea *O. Müll.*, mentd., 263.
— gibba (*Ehrbg.*) *O. Müll.*, 262; mentd., 254.
— gibberula (*Ehrbg.*) *O. Mull.*, 262; mentd., 250, 253.
— — var. rupestris (*Grun.*) *O. Mull.* f. crassa *O. Müll.*, 262; mentd., 253.
— — var. Vanheurckii *O. Müll.*, 262.
— gracilis *O. Müll.*, 262; mentd., 252, 253.
— hirudiniformis *O. Müll.*, 262; mentd., 251, 253, 254, 263.
— musclus (*Kütz.*) *O. Müll.*, mentd., 262.
— ventricosa (*Grun.*) *O. Müll.*, 262; mentd., 253.
— vermicularis *O. Müll.*, mentd., 251.
— — f. recta *Rich* *, 262; mentd., 254.
Rich, F., Algae from the East African Lakes (Cambridge Expedition), 249–275.
Rivularia Biasolettiana *Menegh.*, 267; mentd., 253.
Rosalina bertheloti d'Orb.†, 561.
— *globularis* d'Orb.†, 562.
— *opercularis* d'Orb.†, 562.
Rotalia beccarii (*Linn.*) †, 567.
Rotalia clathrata *Brady* †, mentd., 566.
— (*Turbinulina*) *elegans* d'Orb.†, 567.
— howchini *Chapm., Parr & Collins* † *, 566.
— *papillosa* var. *compressiuscula* Brady †, 566.
— *papillosa* var. *compressiuscula* Howchin†, 566.
— *reticula* Heron-Allen & Earland †, 566.
— reticulata *Cushm.*†, mentd., 566.
Rotalina *partschiana* d'Orb.†, 567.
— reticulata *Czjzek* †, mentd., 567.
— *ungeriana* d'Orb.†, 571.
Rotaria neptunoida Harring, 241.
Rotifer Fauna associated with the Phytoplankton of twenty-eight Lowland Waters (Griffiths & Cocks), 465–471.
Rotifer neptunius *Milne*, 241.
Rotifères from the East African Lakes (de Beauchamp), 231–248.
Roubaudiella Ség., 395.
— *caerulea* Ség., 405.
Rudra baurensis *Badcock* *, 4, 46.
— polita *Peckham*, mentd., 47.

Sacculina, mentd., 473, 532, 533, 536, 537.
— abyssicola *Guérin-Ganivet*, mentd., 518.
— *aculeata* Boschma, 504.
— anceps *Boschma*, 527; mentd., 529.
— atlantica, 511.
— *benedeni* Popov, 489, 490.
— bicuspidata *Boschma*, 527; mentd., 529.
— bucculenta *Boschma* *, 498, 501.
— caelata *Boschma*, 498; mentd., 499.
— calappae, mentd., 523.
— carcini *Thomps.*, 489, 494.
— comosa, 511.
— compressa, mentd., 489.
— confragosa *Boschma* *, 494.
— corculum, mentd., 505.
— crucifera *Kossm.*, mentd., 505.
— duracina *Boschma* *, 483.
— echinulata *Van Kampen & Boschma*, 518.
— elongata *Boschma* *, 515.
— eriphiae, mentd., 513.
— exarcuata *Kossm.*, 507.
— flexuosa *Kossm.*, 527, 529.
— *galatheae* Norman & Scott, 545.
— glabra *Van Kampen & Boschma*, 498; mentd., 499.
— gonoplaxae *Guérin-Ganivet*, 518, 519.

Sacculina hirsuta *Boschma*, 518.
— hirta *Boschma* *, 511.
— hispida, 511.
— hystrix, mentd., 523.
— inflata *Leuckart*, 515; mentd., 513.
— leopoldi *Boschma*, 518.
— micracantha, 511.
— microthrix, 494.
— muricata, 494.
— *neglecta* Fraisse, 537.
— nodosa, 494.
— *pauli* Popov, 489, 490.
— pertenuis *Boschma* *, 498, 499.
— *phalangi* Norman & Scott, 537, 538.
— *pilosa* Van Kampen & Boschma, 488, 504, 538.
— pilosella, mentd., 489.
— plana *Boschma* *, 524.
— pustulata *Boschma*, 527; mentd., 529.
— rotundata *Miers*, 504; mentd., 473, 488, 489.
— rugosa *Van Kampen & Boschma*, 527; mentd., 529.
— scabra *Boschma*, 498; mentd., 499, 501.
— *similis* Guard & Bonnier, 489.
— sinensis *Boschma* *, 490, 494.
— spinosa *Van Kampen & Boschma*, 518.
— sulcata *Van Kampen & Boschma*, 527; mentd., 519, 529.
— teres *Boschma* *, 520.
— *triangularis* Anderson, 515.
— vankampeni, mentd., 489.
— verrucosa, mentd., 523.
— weberi, 494.
Salifa perspicax *Blanch.*, 299.
Scapsipedus marginatus *Afz. & B.*, 594.
Scaridium longicaudum (*Mull.*), 468.
Scenedesmus, mentd., 465, 466.
— arcuatus *Lemmerm.* var. platydisca *G. M. Smith*, 256; mentd., 255.
— bijugatus (*Turp.*) *Kutz.* f. arcuata (*Lemmerm.*) *W. & G. S. West*, mentd., 256.
— obliquus (*Turp.*) *Kütz.*, 256; mentd., 252.
— opoliensis *P. Richter* var. carinatus *Lemmerm.*, 256; mentd., 255.
— protuberans *Fritsch & Rich*, 256; mentd., 254, 255.
— quadricauda (*Turp.*) *Bréb.* var. bicaudatus *Hansg.*, 256; mentd., 255.
Schilbe mystus (*Linn.*), mentd., 129.
— uranoscopus *Rüpp.*, 129.
Schubotzia eduardiana *Blgr.*, 313, 340.
Scintharista notabilis brunneri *Sauss.*, 607.
Scorpio crassicauda Olivier, 92.
Scorpions collected by Mr. Bertram Thomas in Arabia (Finnegan), 91–98.
Scott, Hugh, communication by (Uvarov), 591.
Scytonema sp., 267.
Septosaccus, mentd., 535.
Sesarma (Holometopus) benedicti *Rathb.*, mentd., 532–535.
Sesarmaxenos, mentd., 536, 537.
— gedehensis *Feuerborn*, mentd., 536.
— monticola *Annandale*, mentd., 536.
Sigara hieroglyphica kilimandjaronis (*Kirk.*), 346.
— sjöstedti (*Kirk.*), 346.
Sigmoidella *Cushm. & Ozawa* †, 555.
Sigmoïlina *Schlumb.*†, 557.
Siphonina australis *Cushm.*†, 567.
— tubulosa *Cushm.*†, mentd., 567.
Sitticus brutus *Badcock* *, 4, 40.
— pubescens *Simon*, mentd., 40.
Somomyia Rond., 395; mentd., 390.
— *amazona* Big., 423.
— *japonica* Big., 408, 409.
— *jeddensis* Big., 400.
— *mutabilis* Big., 423.
— *nebulosa* Big., 406 408.
— *obesa* Big., 408, 409.
— *orenoquina* Big., 423.
— *pachysoma* Big., 408.
— *pallidibasis* Big., 426.
— *pallifrons* Big., 413.
— *pueblensis* Big., 423.
— semiviolacea *Big.*, mentd., 424.
— soulouquina *Big.*, mentd., 424.
— *sylphida* Big., 423.
Spalacomimus inermis *Uv.**, 592, 599.
— talpa, 600.
Speluncacris pilipennis (*Chop.*)*, 595.
Spercheus *Klug.*, 303.
— emarginatus *Schall.*, mentd., 303.
Sphaeroidina bulloides *d'Orb.*†, 568.
Sphagnum, mentd., 469, 470.
Sphingonotus rubescens (*Walk.*), 592, 609.
Spirillina *Ehrbg.*†, 554.
— decorata *Brady* †, 558.
— inaequalis *Brady* †, 559.
— limbata *Brady* †, mentd., 559.
— — var. *papillosa* Cushm.†, 559.
— — var. tuberculolimbata *Chapm.*†, 559.
— pectinimarginata *Chapm., Parr & Collins* † *, 558.

Spirillina spinigera *Chapm.*†, mentd., 558.
— *tuberculolimbata* Chapm.†, 559.
— vivipara *Ehrbg.*†, 558.
Spirobranchus sp., mentd., 145.
Spirogyra sp., 257; mentd., 251, 252, 254.
Spiroloculina *d'Orb.*†, 557.
— affixa †, 556; mentd., 557.
Spirontocaris polaris (*Sab.*), mentd., 546, 547.
— pusiola (*Kröyer*), mentd., 546, 547.
— spinus (*Sowerby*), mentd., 546, 547.
Spirophthalmidium *Cushm.*†, 556; mentd., 557.
Spiroplecta spp.†, 557.
Spirulina, mentd., 251.
— laxissima, mentd., 204.
— major *Kütz.*, 269; mentd., 254.
— *platensis* (Nordst.) Geitl., 269.
— subtilissima *Kütz.*, 269; mentd., 254.
Staurastrum brachiatum, mentd., 469.
— Dickiei *Ralfs*, 258; mentd., 252.
— — var. circulare *Turner*, 258; mentd., 252.
— — var. maximum *W. & G. S. West*, mentd., 258.
— limneticum *Schmidle*, mentd., 250.
— Ophiura *Lund.*, mentd., 250.
— paradoxum *Meyen*, 258; mentd., 253, 254.
Staurogenia rectangularis A. Br., 256.
Stenorhynchus longirostris, mentd., 538.
— rostratus, mentd., 538.
Stephanodiscus astroea (*Ehrbg.*) *Grun.*, 259.
Stichococcus subtilis Klercker, 257.
Sulcator Spence Bate, 363.
— *norvegica*, 363, 368.
Surirella biseriata *Bréb.*, mentd., 250, 251.
— — var. lanceolata *Rich* *, 264; mentd., 253, 259.
— — var. subconstricta *Meister*, 264; mentd., 251, 253, 254.
— — var. subparallela *Meister*, 264; mentd., 253, 254.
— — var. vulgaris *Meister*, 264; mentd., 253.
— linearis, mentd., 251.
Sylon, mentd., 537.
— hippolytes *M. Sars*, 546.
Symphalangus, 438–440.
Synalpheus, mentd., 550.
— brucei, mentd., 547, 549.
Synchaeta oblonga *Ehrbg.*, 468; mentd., 470, 471.
— pectinata *Ehrbg.*, 468; mentd., 469–471.
— stylata *Wierz.*, 468; mentd., 469, 471.
— tremula (*Müll.*), 468; mentd., 471.
Synedra sp., mentd., 195, 250.
— acus *Kütz.*, 259; mentd., 254.
— — var. angustissima *Grun.*, 259; mentd., 254.
— ulna (*Nitzsch.*) *Ehrbg.* var. subaequalis *Grun.*, 259; mentd., 254.
Syrisca agalenoides *Badcock* *, 4, 32.
— (Teminius) braziliana *Keys.*, mentd., 32.

Tabellaria, mentd., 250.
Temora, mentd., 368.
Tertiary Foraminifera of Victoria, Australia.—The Balcombian Deposits of Port Phillip. Part III. (Chapman, Parr & Collins), 553–577.
Testudinella parva (*Ternetz*), 468; mentd., 469, 471.
— patina (*Herm.*), 468; mentd., 470, 471.
— truncata (*Gosse*), 468; mentd., 469.
Tetraëdron minimum (*A. Br.*) *Hansg.* f. apiculatum *Reinsch*, 255; mentd., 253.
Tetragnatha antillana *Simon*, 3, 14.
— decipiens *Badcock* *, 3, 13.
— extensa *Linn.*, mentd., 13.
— parva *Badcock* *, 3, 14.
Tetramastix opoliensis *Zach.*, 240.
Textularia *Defrance* †, 557.
Thalamita prymna, mentd., 547, 549.
Thaumastoderma, mentd., 244.
Thompsonia, 547; mentd., 473.
— affinis *Krüger*, 547; mentd., 549.
— chuni *Häfele*, 547; mentd., 548.
— dofleini *Häfele*, 547; mentd., 548.
— globosa *Kossm.*, 547; mentd., 548, 549.
— japonica *Häfele*, 547; mentd., 548, 550.
— sinensis *Keppen*, 547; mentd., 548.
Thylacoplethus edwardsi *Coutière*, 547; mentd., 548.
— haddoni *Coutière*, 547; mentd., 548.
— heurteli *Coutière*, 547; mentd., 548.

Tilapia, mentd., 192, 202, 208, 210.
— eduardiana, mentd., 317.
— esculenta *Graham*, 312, 317; mentd., 310, 311, 314, 320.
— galilaea (*Artedi*), 312, 317; mentd., 314.
— *guiarti* Pellgr., 339.
— inducta *Trew.**, 313, 317.
— leucosticta *Trew.**, 313, 318; mentd., 311.
— *macrops* Blgr., 333.
— *martini* (part.), Blgr., 330–332.
— nigra (*Günther*), 312, 317; mentd., 141, 145.
— nilotica (*Linn.*), 312, 313; mentd., 145, 310, 315–318, 320.
— *pappenheimi* Blgr., 330, 334.
— variabilis, mentd., 310, 311, 314, 318, 320.
— vulcani *Trew.**, 312, 315.
— zillii (*Gervais*), 312, 320; mentd., 310.
Trachelomonas hispida (*Perty*) *Stein*, 265; mentd., 255.
Trewavas, E., Cichlid Fishes from the East African Lakes (Cambridge Expedition), 309 341.
Triangulus munidae Smith, 545.
Triarthra (Filinia) longiseta *Ehrbg.*, 240.
— — var. limnetica *Zach.*, 240.
Trichocerca cristata *Harring*, 468.
— iernis (*Gosse*), 468.
— longiseta (*Schrank*), 468.
— pusilla (*Jenn.*), 468.
— (Rattulus) stylata *Gosse*, 232.
Trichotria pocillum (*Mull.*), 468.
— tetractis (*Ehrbg.*), 468.
Tridactylus variegatus *Latr.*, 594.
Trifarina *Cushm.*†, 555.
Trigonidium cicindeloides *Ramb.*, 594.
— simiolus *Karsch*, 594.
Trilobus diversipapillatus *Daday*, 56, 57, 63; mentd., 69.
— gracilis *Bastian*, mentd., 65, 69.
— *longus* Cobb, 63.
— parvipapillatus *Kreis* *, 55–57, 67.
Triloculina *d'Orb.*†, 557.
Trilophidia sp., 609.
Trimerseurus monticola *Günther*, mentd., 222.
Trionyx triunguis (*Forsk.*), 229; mentd., 213.
Tristria sp., 612.
Truncatulina *lobatula* (Walk. & Jacob) †, 570.
Truncatulina *mundula* Chapm. & Crespin †, 571.
— — var. *carinata* Chapm. & Crespin †, 571.
— *reticulata* Howchin †, 567.
— *ungeriana* (d'Orb.) †, 571.
— variabilis *d'Orb.*†, mentd., 572.
Tubinella *Rhumbler* †, 557.
Tylopsis sp., 597.
Tylotropidius gracilipes *Brancs.*, mentd., 614.
— speciosus (*Walk.*), 614.

Urothoe, mentd., 386.
— norvegica, mentd., 363, 368.
Utricularia, mentd., 137, 179.
Uvarov, B. P., Entomological Expedition to Abyssinia, 1926–7: Orthoptera of the families Mantidae, Gryllidae, Tettigoniidae, and Acrididae, 591–614.
Uvigerina *d'Orb.*†, 555.

Vaginulina *d' Orb.*†, 554.
Varanus ocellatus *Rupp.*, 225; mentd., 214.
Varuna litterata, mentd., 532.
Vectius niger (*Simon*), 4, 30.
Virgulina *d'Orb.*†, 555.
Viridinsula Sm., 392, 395, 399.
Volvocales of South India (Iyengar) [Title only], 472.

Wallaba forest, 585.
Worthington, E. B., communications by (Beadle), 135, 157, 347; (de Beauchamp), 231; (Jaczowski), 343; (Lundblad), 277; (Moore), 297; (Parker), 213; (Trewavas), 309; Scientific results of the Cambridge Expedition to the East African Lakes. 1. General introduction and station list, 99–119; 2. Fishes other than Cichlidae, 121–134.

Xenopithecus †, 441, 461; mentd., 462.
— koruensis *Hopwood* †, 441.
Xenopus laevis (*Daudin*), 215.

Zacompsa sp., 604.
— brevipennis *Mill.*, mentd., 604.

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